SCIENCE TEACHER'S WORLD

Teacher's edition of SCIENCE WORLD December 9, 1959

Using *Science World* in Your Teaching

Diamonds from the Sky (pp. 6-8)

General Science and Earth Science Topic: Clouds
Biology Topic: Ecology
Physics Topics: Change of state, crystal structure

About This Article

How varied are the manifestations of water in nature! Water may appear as a glass-clear fluid, a billowy cloud, a wisp across the blue sky, a foamy wave, a glistening icicle, or a decorative "plant" on a frosty window pane. One of these manifestations, marvelous to behold when examined closely, is a snowflake. Although always six-sided, there seems to be no end to the variety of its lacework. What is more, these exquisite jewels appear out of thin air and can disappear into thin air. The conditions under which they thus appear, the chemistry underlying their shapes, their growth, their fall, and the part they play in protecting plants and animals from the rigors of the atmosphere —these are the subjects of this article.

Topics for Class Discussion

1. Explain why a snowflake is generally six-sided.
2. How does a cloud made of snowflakes disappear?
3. Under what conditions does the water in the atmosphere form rain? hail? snow? graupel?
4. How does a snowflake grow?
5. Explain why snow is a good insulator against loss of heat.
6. What evidence is there that some forms of life can thrive under snow?

Hibernation (pp. 9-11)

General Science Topic: Survival of plants and animals
Biology Topics: Metabolism, adaptation, ecology, hibernation, and estivation

About This Article

Hibernation, like migration, is an adaptation of living organisms that challenges the biologist who wants to know: (1) How a given organism—say, the ground squirrel—developed this adaptation; (2) What is responsible for the onset of the series of metabolic changes by which an animal goes into hibernation, or comes out of it. It would seem that every time a factor is identified as being involved, exceptions are found to indicate that there is more to be explained. And so, hibernation—and estivation, too—remain active areas of research.

In the course of this research, metabolic changes have been noted in animals going into hibernation. The habits of hibernating animals have been studied in attempts to discover correlations between metabolic changes and changes in temperature, humidity, atmospheric pressure and the like. Attempts have even been made to reproduce these conditions so as to get animals to hibernate. The article is a brief review of some of these research studies. As the author points out, it may very well be that this research will yield information that may be applicable in medicine and surgery.

Teaching Suggestions

With biology classes, this article might be used as a "special report" assignment in connection with any of these topics: respiration, rate of heartbeat, rate of metabolism, endocrine glands, the role of fats in body metabolism, adaptation to changes in environment.

High Pressure (pp. 12-15)

General Science Topics: Solids, liquids and gases, the sun and its family, Project "Mohole."
Earth Science Topic: The Earth's interior
Physics and Chemistry Topics: High pressure phenomena, change of state, crystalography, nuclear fusion
Chemistry Topics: Forms of carbon, metals and non-metals.

About This Article

A favorite way to drive home the fact that our world is conditioned by temperature is for the teacher to get his class to contemplate what would happen to the oceans, the mountains—to everything on Earth—if the Earth were to move closer and closer to the sun; or what would happen to the atmosphere, the oceans and to all life if the Earth were to move farther and farther from the sun.

Comparable speculation to drive home the fact that our world is conditioned also by *pressure* is more difficult to engender for this reason: while students come to the science class with a considerable background of experience with effects of temperature change—evaporation, freezing, boiling, melting, hardening—they come with very little experience having to do with effects of *pressure* on matter. This article can serve to provide—vicariously, to be sure —something of this experience. The reader is led to comprehend that the matter about us and in us is conditioned as much by the pressure range in which we find ourselves as by the temperature range.

Advances in technology are greatly expanding our powers to increase pressures to unprecedented magnitude, and to observe their effects on matter. These observations are shedding light on some significant problems in physics, chemistry, geology, and astronomy.

Topics for Class Review

1. What is Borazon? How is its name derived? What are its unique properties? How is it made?
2. Why are high pressures for experi-

Memo from IBM®

Bright balls bouncing into a slot: A game—and a tool of science. The pins and the balls represent a Galton Probability Board. The probable distribution of balls, scientist Francis Galton showed, matches distribution in the population of such human characteristics as height or head size.

A game—and a tool of science. A description of probability itself. This branch of mathematics has always fascinated gamblers and scholars alike. Cardano, first to write about it in the 16th century, was a gambling mathematician and a cheat at that. Even pious Blaise Pascal became interested almost a hundred years later through a problem posed by his friend, the Chevalier de Méré: A dice game in which a fixed number of points was required to win was left unfinished with one player ahead. How could the stakes be divided fairly?

His creative imagination in high gear, Pascal wrote his fellow mathematician, Pierre de Fermat. The resulting correspondence launched probability as one of the most important branches of mathematics. Summarizing his studies in 1654, Pascal made use of the now famous number triangle shown in the picture. The number at each end of a row is always one. Each number in between is the sum of the two numbers just above it.

Vastly developed by such towering mathematicians as Jacob Bernoulli, Pierre de Laplace, Karl Gauss, probability has since proved invaluable in one important field after another. Two examples:

In physics, James Clerk Maxwell used the laws of probability to describe theoretically the movements of gas molecules that could not be actually measured. The result was an accurate prediction of how gases behave.

• In genetics, the Abbe Mendel showed that the characteristics of plants resulting from crossbreeding follow the laws of probability. When green and yellow peas are crossed and the resulting hybrids inbred, the color genes of the next generation will be distributed according to Pascal's odds for heads and tails in tossing two coins.

Probability today is the tool not only of scientists, but of economists, statesmen, generals, business executives. The gambler's guide has not become merely respectable. It is indispensable.

mental purposes difficult to attain? How *are* such pressures attained?

3. Explain why it is more difficult to compress a liquid than to compress a gas.

4. Explain how crystal structure changes as a solid is compressed.

5. What is the role of chromium in the manufacture of diamond from graphite?

6. Explain this statement: "There are seven kinds of ice."

7. How does the compressibility of caesium compare with that of diamond?

8. Explain how theories of mineral formation can now be tested in the laboratory.

9. What is Project "Mohole"?

10. What major problem would have to be solved before Project "Mohole" could succeed?

Tomorrow's Scientists (pp. 21-24)

William Barry's report on aeroembolism offers the science teacher the opportunity to call attention to the ramifications involved in what would appear to be a simple problem. William's exploration of the problem of aeroembolism led him into fields of physics, chemistry, physiology, mathematics, and—if we consider his testing chamber —also engineering.

Some of the background information contained in William Barry's report will be found as interesting as his main thesis; for example, his calculations that show the human body to have sweat pores equivalent to 8 sq. in. of opening, his list of gases that contribute to bubble formation in embolism, and the like. William evidences, to a marked degree, a significant element found in the science-talented; namely, the predilection to think in quantitative terms.

Today's Scientists Man Against Microbes (p. 20)

Of Selman Waksman it may be said that he is an intellectual descendant of the great Louis Pasteur, the father of microbiology. Pasteur wondered how it was that soil in which diseased corpses are buried is singularly free of the pathogenic organisms that killed these animals. Waksman, inspired by his great teacher, Dr. Lipman, pursued this problem by studying the microbial inhabitants of the soil—a world in itself. He studied the biology of individual species and the relationships among species. Out of these studies came the discovery of the antibiotic streptomycin.

Pasteur lived to see his work give rise to a great scientific institution in Paris—the famous Pasteur Institute. Dr. Waksman, too, lives to see a dream of his come true—the Institute of Microbiology at Rutgers University—an institution where scholars and investigators for many years to come will continue to study a very basic segment of the biotic world.

The review of the life of this scholarly and dedicated scientist and benefactor of mankind will inspire students in classes of every secondary school science.

Meeting the Test (p. 26)

The cry today is "Let's upgrade our science teaching!" One way of "upgrading" is to make our science courses in the schools more quantitative. In this connection, do not overlook Dr. Benjamin's *Interpreting Relationships in Graphs.* His piece has some important implications for science teaching. One implication is that we should include in our courses opportunities for pupils to collect data and express relationships in the form of graphs. By the same token, we should give pupils exercise in making (composing, not copying) diagrams of abstract ideas and relationships. Another implication is that we should try to work into our tests questions patterned after those presented in this article.

Career Guidance

The full-page message on page 2 of the student edition is another in the continuing series sponsored by International Business Machines. Purpose of this series is to show historical breakthroughs in mathematics and science, and to interest students in careers in these fields.

Science Talent Search

Steadily increasing interest in scientific training and professional careers is reflected in the growing number of students competing in the annual Science Talent Search for the Westinghouse Science Scholarships and Awards, according to Watson Davis, director of Science Service.

More than 33,000 sets of entry materials have been requested by the teachers and counselors of outstanding high school seniors who wish to compete in the 19th Science Talent Search. This represents an 18 per cent increase, reports Dorothy Schriver, executive secretary of Science Clubs of America, which conducts the Search as an activity of the Science Service science youth program.

Approximately 10 per cent of students who fulfill all entry requirements will be named members of the Honors Group. From this group, 40 top winners will be selected to come to Washington for the Science Talent Institute, March 3 through March 7, 1960.

SCIENCE WORLD

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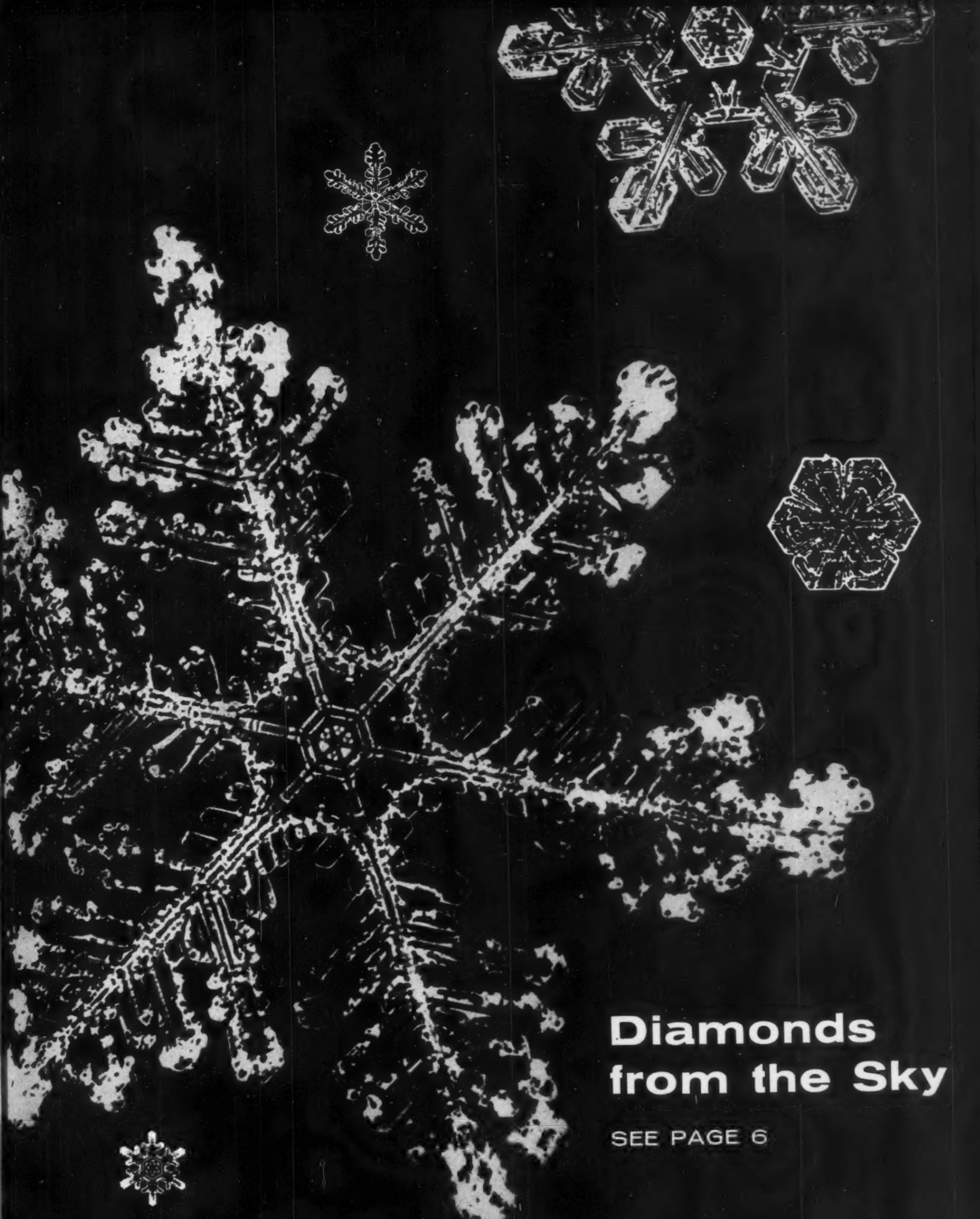
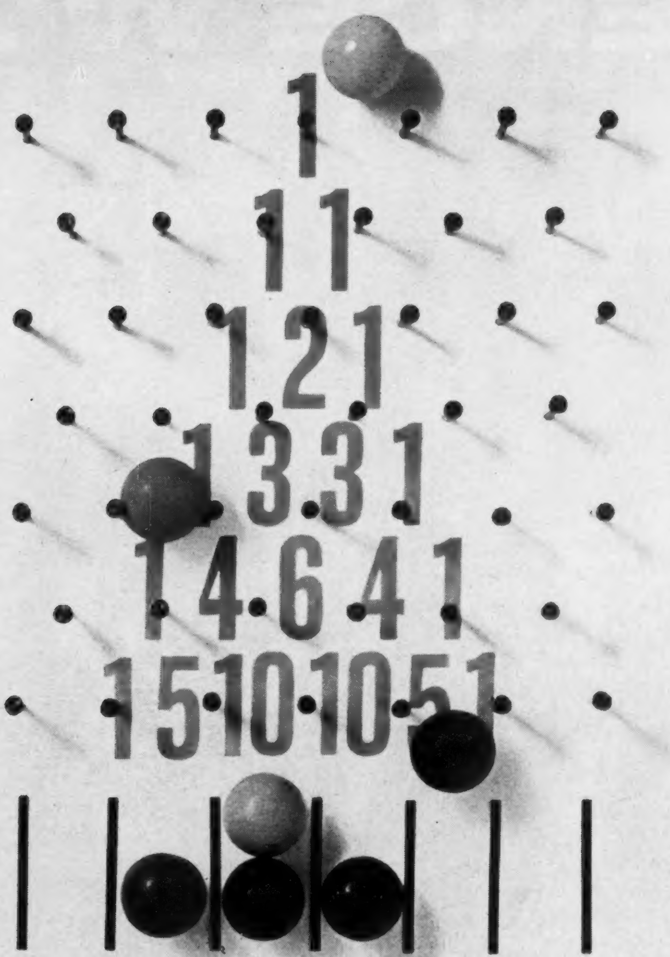


Diamonds from the Sky

SEE PAGE 6

MATHEMATICS SERVING MAN



MATHEMATICS OF CHANCE: What are the chances that the top ball will fall into the left-hand slot? A trivial point? Not to a great mathematician. When the deeply religious Blaise Pascal answered a similar question to settle a gambler's argument in seventeenth century Paris, he gave mathematics one of its most important tasks—prediction. Using Pascal's famous triangle of numbers,* the probable number of times that a given event will happen by pure chance can be determined. In the 300 years since then, the mathematical laws of probability have helped establish the insurance business, enable scientists to predict the molecular behavior of gases, forecast the results of cross-breeding plants or animals, analyze the value of a new serum. The mathematical insight that made all this possible is now being applied to weather forecasting, psychological testing and public opinion research. Probability has become a science that calculates in advance the chances of success of an untold number of events for man's benefit.

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*For example, the third line from the tip of the triangle tells us there are four different ways two coins can land: the chance of both falling heads up is 1 in 4; of one head and one tail, 2 in 4; and of two tails, 1 in 4.

It happens before enlistment

Meteorological Observer

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Letters

Scar Tissue

Dear Editor:

Is scar tissue living or dead?

Ruth Glisson
210 Gorden Street
Jackson, Tennessee

Answer: A scar is a mark left by the healing of an injury due to a burn, ulcer, cut, or other similar cause. Scar tissue also is found on plants. When a leaf falls from a stem or branch, a scar is left.

Scar tissue is made of dead cells. In some cases scar tissue can be removed from human skin. The only mark remaining is an indentation.

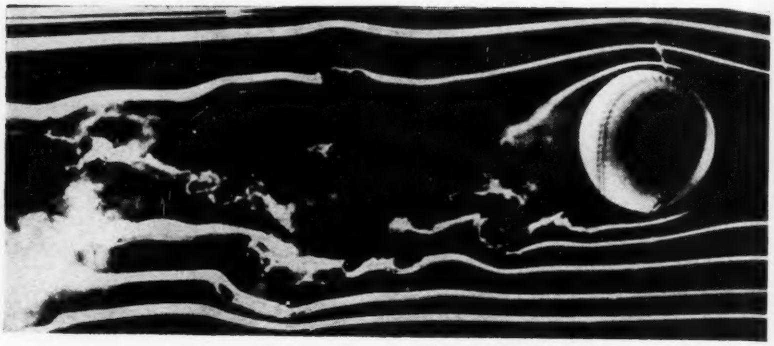

Photo from Prof. F. N. M. Brown, Notre Dame, Indiana

Baseball spins counterclockwise in wind tunnel. Wind is coming from the right.

"Sleeping" Hands

Dear Editor:

Why when a person falls asleep on his hand or sits on his foot for a period of time does it go to sleep?

Keith B. Makay
16311 S. F. Mission Blvd.
Granada Hills 8, California

Answer: The pressure of your body against either your hand or foot stops the circulation of the blood. With no circulation in an organ it develops a feeling of numbness.

More on Quoddy Project

Dear Editor:

The Passamaquoddy Tidal Power Project means a great deal to the state of Maine. We high school students will be getting jobs that are to be created by the use of the tidal power in Passamaquoddy Bay. We therefore object to a portion of your article about this project in the November 4, 1959 issue of *Science World.*

In this issue you stated, "All tidal power stations face one big drawback—they can generate electricity only when the tides are flowing in or out. For about twelve out of every 24 hours, when the tide is low, the tidal turbines would be silent." This statement is not true so far as the Passamaquoddy Tidal Project is concerned. This project uses a two-pool system that provides power at all times. At no time are all of the generators shut down.

In the two-pool scheme the high pool is refilled at each of the two high tides that occur daily. The low pool has water removed from it when the tide is low. This occurs twice daily, too. The water can flow between the high and low pools to produce power at all times, regardless of the level of the tide in the outer ocean.

You are correct when you said that an upriver storage plant would be used to aid the power produced by the tides. This plant is necessary even though a large quantity of power will be produced by the tidal plant at all times. The upriver plant will steady the tidal plant power output, which does vary with tidal conditions.

Carol A. Clark
79 South Street
Calais, Maine

Answer: Thank you very much for rounding out our article. A system with a high and low pool would definitely allow the continuous generation of electric power at any time during the motion of the tides. As far as we know, the Passamaquoddy Project is the only tidal power station which plans to use this system.

Oldest Living Thing

Dear Editor:

What is the oldest living thing on earth?

Diane Ray
South Woods Jr. High School
Syosset, New York

Answer: The oldest living thing which scientists have so far identified is a tree known as the bristlecone pine, recently found in Inyo National Forest in California. A grove of these trees was found to be 4,000 years old or more. The age of the trees was determined by counting the annual growth rings. The bristlecone pines were found growing in the dry thin air of highlands, at an altitude of 10,000 feet. In such an environment, the tree's growth is stunted, and it adds no more than an inch per century to its girth. With so little growing tissue to nourish, the trees can survive lean years and maintain their life over the centuries.

Why a Ball Curves

Dear Editor:

What makes a baseball curve?

Richard Uhrich
405 South First Street
Hillsboro, Oregon

Answer: In order for a baseball to curve, it must be traveling forward and at the same time spinning on its axis. As the ball spins, air pressure increases on the side of the ball turning in the direction in which the ball is traveling, and decreases on the other side. This is because of the friction between the surface of the ball and the air. The friction causes one side of the spinning ball to throw air against the onrushing air stream, and the other side to throw air with the onrushing air stream. This lowers the air pressure on the side turning with the air stream and raises it on the other, making the ball curve away from a straight path.

What determines the curve is how fast the ball spins, not how fast the ball is speeding toward home plate. The National Bureau of Standards found that the greatest curve is obtained when the ball spins at 1,800 revolutions per minute and travels at 68 miles per hour. The fastest pitch ever measured was tossed by Bob Feller, at 98.6 miles per hour.

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The Staff

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Cover photograph by Dr. Vincent J. Schaefer

Science in Quotes

Science has its showrooms and its workshops. The public today, I think rightly, is content to wander round the showrooms where the tested products are exhibited. But we need to see what is going on in the workshops. You are welcome to enter; but do not judge what you see by the standards of the showroom.

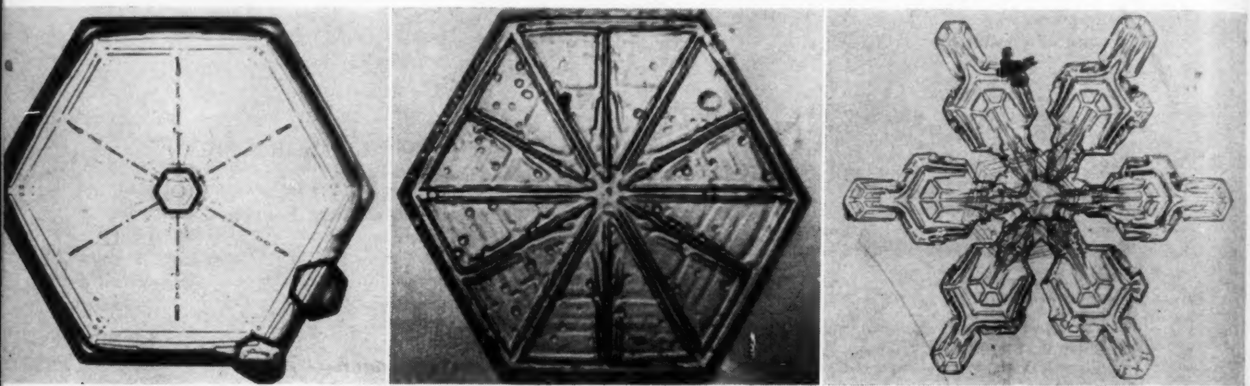
We have been going round a workshop in the basement of the building of science. The light is dim, and we stumble sometimes. About us is confusion and mess which there has not been time to sweep away. The workers and their machines are enveloped in murkiness. But I think that something is being shaped here—perhaps something rather big. I do not quite know what it will be when it is completed and polished for the showroom. But we can look at the present designs and the novel tools that are being used.

—SIR ARTHUR EDDINGTON

By ELIOT TOZER

The delicate snowflake, a crystal of water vapor, is produced by a complex process

Diamonds from the Sky



Photos from Dr. Vincent J. Schaefer

Dr. Vincent Schaefer has developed a method of preserving snowflake patterns. He coats snowflake with plastic on glass slide. Plastic hardens into thin shell around snowflake. Snowflake evaporates, leaving behind a replica of pattern.

IT SNOWS all the time—even in July.

If you have ever seen a filmy strand of cirrus cloud against a summer sky, you have seen a snowstorm in July. For cirrus clouds are not made of water droplets as are other clouds. They are made of ice—blue, white, and yellow needles of ice. If these tiny crystals were to fall to earth, you would recognize them as snowflakes.

But the crystals in the clouds in our upper troposphere (25,000-40,000 feet) seldom spiral down to earth. They cascade into warmer levels of air. There they evaporate and are swept back upward to recrystallize. They are so small, so feathery light, they rarely fall.

The snow that spirals down to our streets and fields falls from the towering cumulonimbus clouds that develop on the leading edge of a fast-moving cold front. Or it showers down from the massive nimbostratus and altostratus clouds that form when warm, moist air rides up over the trailing edge of a retreating mass of cool air.

Such cold and warm fronts will sweep over us more and more frequently now that winter is almost here, but only a few of them will produce snow. For the tiny blue-white crystals are the end result of a most unusual process—sublimation. A snowflake is a crystal of water vapor that has passed directly from the gaseous to the solid state without going through the intermediate step of becoming a liquid.

Rain is produced by the condensation of water on hygroscopic nuclei (airborne particles of clay, soot, and the like that absorb water). Hail grows layer by layer as frozen raindrops collide with droplets of water that are supercooled—cooled below the freezing point.

The Structure of Snow

The crystallization of water vapor to snow is a complex process in which the temperature, pressure, and vapor content of the air must be in critical balance. If all these substances and conditions happen to fall into place at the same time, like the parts of a picture puzzle, it will snow—even in "sunny" Florida, as it does about every five years.

Scientists are learning more and more about how in most solids the molecules are locked together rigidly in what we identify as crystals. These crystals are built on a regular geometric pattern. Identical atomic units appear over and over again in these crystals, like the design in wallpaper. Table salt, for example, is a crystal that is shaped like a cube, with the atoms of sodium and chlorine locked in place in perfect rows. This arrangement of the atoms, the strength of the force that binds them, and the shape of the crystal give any solid some of its characteristic properties. They make a diamond hard, for example, and copper a good conductor.

Scientists working in nature's "laboratory" have found that crystals of snow are built up of water molecules. Each water molecule is made up of three atoms—two of hydrogen and one of oxygen. The whole molecule has two positive electrical charges and one negative charge. When the molecules come together to form a snowflake, the negative charge of one molecule is always attracted to one of the positive charges of another molecule, to form a solid pattern. Thus crystals of snow always take the triangular shape from which the familiar six-pointed snowflakes evolve. (Some flakes, however, may have only

three points and others may have as many as twelve.) From this shape, and from the arrangement of atoms in the crystal, snowflakes get their slipperiness, and the tendency to interlock so firmly with other flakes that you can carve a safe tunnel through a snowdrift.

But how is the crystal itself formed?

There are two ways to make crystals in the laboratory: (1) by fusing elements at high temperatures and high pressures and then allowing them to cool slowly; and (2) by super-saturating solutions.

Scientists in the General Electric Research Laboratory have been making diamonds by the first method since 1955. Recently they told us the secret (*see page 12 of this issue*): squeeze carbon at pressures between 800,000 and 1,800,000 pounds per square inch at temperatures ranging from 2,200 to 4,400 degrees F. The diamonds' color and shape will vary with the temperature. So too does the color and shape of snowflakes vary with the temperature and pressure at the time the flake was formed.

As for the second method, you have probably used it to make crystals in your school laboratory. If you super-saturate a salt solution, then drop in a crystal, the salt in solution will "crystallize out." This, generally speaking, is the way that snow is formed.

When Snow Is on the Way

You probably know when snow is coming. You can "feel" it. At night there may be a halo around the moon (caused by moonlight shining through high-level ice crystals), and next day you notice that the wind has shifted uneasily to the southeast. The air is warm and damp. It may have a kind of acrid smell. The barometric pressure falls. And the clouds in the west lower quickly and grow dark.

These are signs that a cold front is approaching; that is, cold air is coming toward you and sliding in under the warmer air on the earth's surface. As the warm air rises, it may meet all the right conditions to sublimate its moisture into snowflakes.

First, air must get very cold (usually between –4 and 10 degrees F.) and be full of moisture—as warm air from the surface of the earth often is. And conditions must be such that the vapor does not condense out —even when cooled to its dew point. The air will then become super-saturated by holding more moisture than it normally would at that temperature.

One more condition must be met: the air must also contain hygroscopic nuclei for the super-cooled vapor to crystallize on.

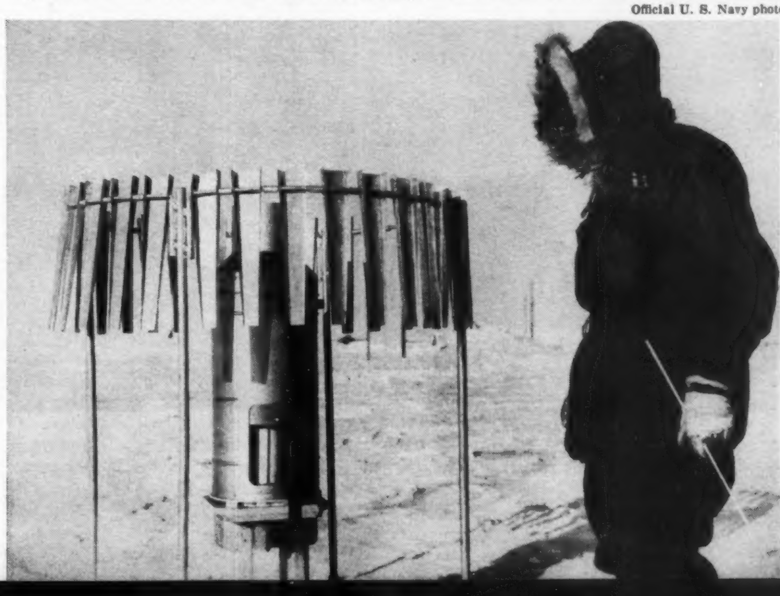
Now, as the air rises, its pressure will drop. When it reaches the right pressure for the formation of crystals at that temperature—if all these things have fallen into place at the right instant—the vapor will sublimate—and we will have a white Christmas.

Rain forms in quite a different way. In the cool middle altitudes, vapor condenses into tiny droplets (about 1/2500th inch) which collide with other drops and combine into bigger and bigger drops that finally splash downward. The moisture goes from vapor to liquid just as it condenses on the side of a cold pitcher on a warm, humid day.

Hail, on the other hand, starts as frozen raindrops and grows by colliding with super-cooled water that turns instantly to ice. It thus picks up layer after layer of ice, like an

Artificial snow is being made in G.E. lab by Dr. Vincent J. Schaefer, scientist who discovered how to make snow from certain types of clouds. Here he is dropping fine particles of silver iodide into a super-cooled cloud of water droplets. Moisture freezes around the silver iodide in shape of snow crystals similar to those found in sky.
Wide World photo

Observer in Antarctica is checking precipitation gauge. Gauge must be protected by screens to prevent wind from removing snow which has fallen into container.
Official U. S. Navy photo



onion, until it is heavy enough to fall through the violent updrafts of the cloud in which it is formed and rattles down to earth. In this instance, the moisture passes from the liquid to the solid state in much the same way that water freezes to ice. Crystals of snow are formed by the short-cut process of sublimation—directly from a gas to a solid.

Here is how a snowflake grows. Starting as a submicroscopic three-dimensional triangle or hollow prism, the snowflake floats for hours, sometimes for weeks, in the middle altitudes, picking up other molecules of vapor and turning them to ice. Gradually, the prism becomes the hub of a three- or six-sided wheel.

Snowflakes Grow and Fall

In the high cirrus clouds, the hub is blue-white and spokes grow on it slowly. Flakes sublimated in the warmer, more moist air below are apt to have a greenish hub and spokes that grow quickly. If the flake stays aloft long enough, each spoke develops beautifully complex spikes and feathers (*see the front cover*).

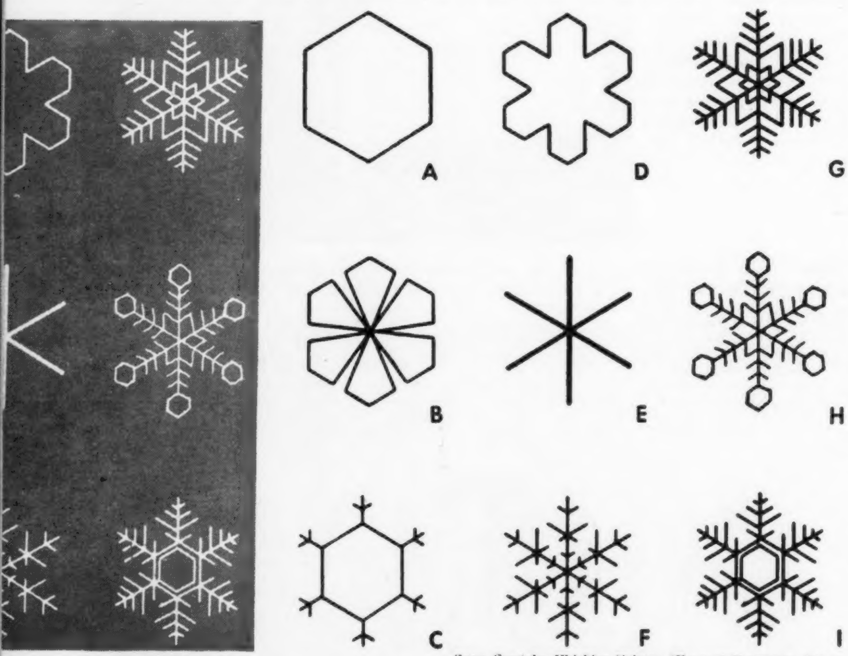
Sometimes the hub grows long, its two ends almost always of different sizes. Then, following the laws of aerodynamics, the flake falls with its small end downward, like a parachute. If it stays aloft many days, threads of crystal may reach downward from the spokes to touch the ends of the hubs and form the soft white pellet called graupel.

Even though it "snows" every month in the Antarctic, little snow is actually crystallized. Ben Harlin of the U. S. Weather Bureau spent a year at the Little America Station during the International Geophysical Year. He recorded an average of about six inches of snow per month, but he thinks the figure is inaccurate because most of the snow that "falls" is really blown snow.

Mr. Harlin tells this story: "With the rapid build-up of snow during February, we thought that the annual cover would be quite deep, so we made a special effort to set up four measuring stakes by March 1. Instead of the continued rapid pile-up, as had been the case in February, a strong southwesterly wind came up on March 2nd, and after several hours almost six inches of snow had been eroded from the surface and blown away." Because Antarctic air is so cold, one element, moisture, is missing from the delicate equation that produces crystals of snow.

To city folk, snow is generally a pain in the back. Shoveling it is a burden. It can even be a menace. But the farmer walks through it to his barn with a feeling of relief. Even the deepest of snows must finally melt. And when it does, the water (about one inch of water from 10 inches of snow) will soak his meadow and fill his farm pond.

But even before it melts, the snow is welcomed by the small animals that do not hibernate, the marmots, ground squirrels, and gophers. To them it is literally a blanket that protects them from the bitter winds. Last winter, scientists at the U. S. Department of Agriculture found that the temperature of the air in Utah's Wasatch Mountains ranged between 2 and 56 degrees F. below freezing, while five feet below the snow, the temperature of the top soil hovered comfortably between 30 and 34 degree F. Even a cover of a few inches, packed as it is with tiny insulating cells of air, keeps soil as much as 30 degrees warmer than the air above.



Snow Crystals, Ukichiro Nakaya (Harvard University Press)

Delicate designs of snowflakes have endless variety. A Japanese scientist, Ukichiro Nakaya, has classified hexagonal (six-pointed) crystals as follows: (a) simple plate; (b) branches in sector form; (c) plate with twigs; (d) broad branches; (e) simple stellar forms; (f) dendritic form; (g) fernlike form; (h) dendritic form with plates; (i) plate form with dendritic extensions.

Snow—the Warm Blanket

Like animals, both plants and seeds are protected by snow. In fact, scientists recently learned that plants and seeds actually grow under the protective blanket. Buds form in the crowns of herbs and grow during the winter, bursting into soft green shoots in the early spring. Some bulbs and tubers produce roots and start to grow in the fall.

Researchers of the Department of Agriculture planted seven different kinds of grass seed under two inches of snow in the Wasatch Mountains and discovered that all had germinated by the end of February. Some roots were over one inch long and some shoots had even poked above ground. Just before the spring melt on May 22, more than 80 per cent of four of the seven grasses had already germinated.

The beautiful displays of crystals in a museum exhibit of rocks and minerals reflect nature's orderliness and apparent design. But even greater beauty can be had with the next snowfall. All you need is a magnifying glass.

By RICHARD BRANDT

Some animals sleep away the winter, living on stored body fat

HIBERNATION–
When Life Stands Still

ONE of the mysteries of the world of nature is hibernation. By what process, with the coming of autumn, do some animals go into the deep sleep which sees them through the unfavorable environment of winter? The question has baffled mankind for centuries.

The little brown bat selects a cave or the hollow of a tree in which to sleep away the winter, hanging by its feet. The woodchuck waddles along the dark tunnels of its underground home to find the highest and largest chamber, there to snuggle down to sleep on a bed of dried grasses. The badger holes up in his tunnel below the frost line to go into a deep sleep.

Scientists describe hibernation as a state of being which borders between simple sleep and death. Ordinary sleep—the eight hours you get each night—is a temporary and *brief* period of relaxation during which only *some* of the body processes slow down. Hibernation, on the other hand, is a kind of sleep in which nearly all the body processes slow down for a long period of time.

Hibernation thus enables some animals to survive months during which food is scarce and the weather inhospitable. If these animals had to maintain their body at a normal rate of activity during such periods, they would soon die of starvation. During hibernation, almost all body

Photo by Lynwood Chace from National Audubon Society

Chipmunk grows drowsy in mid-September at 50° F., curls up in chamber in burrow, goes to sleep. Bit by bit life forces slow down until it looks like dead animal.

movement is suspended. The life processes function at a very slow pace—barely enough to maintain life. The blood temperature lowers as the chemical activity of the animal's body becomes geared to its available energy.

The true hibernators are warm-blooded mammals such as woodchucks and ground squirrels, cold-blooded reptiles, and amphibians such as frogs and toads. The more adaptive animals do not hibernate. They either migrate to another location to obtain food, store food, or "live by their wits."

Body Fat Supports Life

Creatures such as insects and mollusks are not true hibernators. Their periods of inactivity are part of their natural life-cycle. These periods may or may not coincide with food shortages or a hostile environment. Nor are bears true hibernators. Their sleep is not deathlike. Breathing, heartbeat, and body temperature undergo little change.

Within the true hibernator's body many changes take place before and during hibernation. One of these changes is the accumulation of food resources in the form of body fat. The animal accumulates the fat by feeding well during the summer. As autumn approaches, the animal instinctively gorges itself at an even faster pace. The fat which is stored may have to support the animal's life for as long as five or six months. The research of some scientists indicates that the process of hibernation may be triggered by these deposits of fat—rather than by environmental conditions such as lack of food or cold weather.

Besides winter fat, fats of a more specialized nature are found in the true hibernator. Dark-colored fatty tissues develop around the blood vessels in the neck, chest, and other parts of the animal's body. As the months of hibernation pass, these areas of special fat grow smaller in size, at a slower rate than do the other areas of fat.

The animal's general metabolism—the physical and chemical processes by which food is transformed into energy—slows down considerably.

Changes also take place within the animal's circulatory system. Most of the white blood cells move into the walls of the stomach. There these cells absorb and destroy decay bacilli which have been gradually accumulating in the area of the stomach. If this did not take place, putrefaction from decaying food would soon cause death. The white blood cells, after accomplishing this important function, return to the blood stream. Then the hibernating animal begins to get very drowsy. It curls up snugly in its hideaway—either alone or with its group, depending on its habits—and sleeps the winter away.

Should we invade the privacy of a chipmunk's den, we would find that all apparent movement has ceased. The animal's breathing would be very slow; in fact, it would be barely perceptible. Its pulse would be faint. The body temperature would hover between 40 and 57 degrees F. The chipmunk would be insensible to both sound or touch. And so winter passes.

The true hibernator's physical condition can best be described as one in which movement ceases and life is maintained by the continuous absorption of stored up fat.

From scientific observation in the field, let us go to scientific observation in the laboratory.

Four Heartbeats a Minute

Scientists have kept golden hamsters at an environmental temperature of about 41 degrees F. to observe their reactions. At this temperature the hamsters prepared for hibernation, and their body temperature fell to a level close to that of the surrounding air. Then a curious thing occurred. Under ordinary circumstances, a temperature of 41 degrees would cause the fat of the hamsters to solidify. It would become too hard for use as nourishment. However, the scientists observed that the fat was changed to a less saturated form and became liquid. This liquid fat could be used as a source of energy during the animal's winter sleep.

The heartbeat of the hamsters slowed down from 400 beats a minute to about four beats a minute. They breathed at the rate of once every two minutes. Their rate of metabolism, based on their oxygen

Photo by Donald Heintzelman from National Audubon Soc

Little brown bat hibernates in cave hanging by feet, breathes once in 5 minutes. Cave must be between 30° and 40° F. Bat's blood heat is 1° above air in cave.

consumption, dropped to one thirtieth of what it had been in their normal condition.

Several weeks later the hamsters began to tense their muscles for some reason not yet known. This reaction caused the body to produce more heat and consume more oxygen. The animals began to breathe at a more rapid rate. The rate of the heart beat gradually increased, as did blood pressure. At a body temperature of 68 degrees F., "brain waves," absent during hibernation, reappeared. About three hours later the hamsters were fully awake.

But what sets animals to hibernating only at the "right time" of year? To find out, Dr. Eric T. Pengelley and Dr. Kenneth C. Fisher, both of the University of Toronto, kept a squirrel under controlled conditions of temperature, light, and adequate food supply for nearly two years.

The squirrel was housed in a room with a mean temperature of about 35 degrees F. It had an unlimited supply of food and water, ample bedding, and 12 hours of artificial daylight every day. Yet the squirrel persisted in hibernating from October through May. Experiments were carried out with eight other ground squirrels under varying conditions

for shorter periods of time. All the animals showed the same tendency to hibernate only during the autumn-winter season.

What started the hibernation cycle? The scientists eliminated such factors as variations in noise level, barometric pressure, and the water content of the air as having triggered the squirrels' hibernation. They concluded that squirrels possess some kind of "internal seasonal clock" that sets them to hibernating only at the "right time" of year.

Scientists still do not know for sure why certain animals become hibernators, but they have several hypotheses. The phenomenon is obviously related to the protection of animals from the rigors of the winter season when food is scarce. But the sheer need for something, or its value, can never be a cause for it. Like migration (*see Nov. 14 issue*), the process of hibernation appears to be related to the glands of reproduction. In true hibernators these glands are less active during hibernation and not as well developed.

Enigma of Summer Sleep

Hibernation as a winter phenomenon has its counterpart: a summer sleep known as estivation. (The word "estivation" is derived from the Latin *aestivus* – pertaining to summer – and means "to pass the summer in a state of torpor.") Only a few North American animals estivate. Among them are crocodiles and alligators, which go into estivation when their water habitats dry up. They bury themselves in mud until the arrival of the heavy rains of autumn.

Scientists have also performed experiments in estivation, but it too is still an enigma. They have studied a mammal known as the tenrec, which resembles a hedgehog and is found on the island of Madagascar off the east coast of Africa. During the hottest time of the year, when earthworms (the food of the tenrec) become scarce, the tenrec takes a snooze. But in the London Zoo, where food is plentiful and there are no hot spells, the tenrec behaves in the same way whether it needs to or not.

What of the other half of our living world—the plants? Do they hibernate or estivate? Indeed they do. Plants are affected by very low temperatures and by the loss of water through transpiration. Running water to replace this loss is not common in winter.

Perennial plants such as geraniums adapt to these changes by sealing dormant tissues and shedding their leaves. When freezing sets in, ice crystals form in the leaves, penetrate the living cells, and destroy them. Woody plants survive "hard times" by shedding their leaves, exposing to the air only the dead covering of the bark. The protected roots of herbaceous plants, such as oats and other grains, will stay alive even after the parts of the plant above ground have all been killed, dying as far down as the protected root. A desert environment selects for its "greenery" only those plants which can stay alive with very little water. Such plants meet excessive heat and dryness by shedding their leaves or by reducing their activity.

Medical scientists are putting to use this knowledge that the life processes—breathing, heartbeat, digestion—slow down as the temperature falls. They are developing a new technique known as "freeze surgery" or hypothermia. By chilling a patient's body—usually by immersing it in ice water—to temperatures 10 to 15 degrees below the normal 98.6 degrees F., the body's requirements upon the circulatory system are greatly reduced—temporarily. Thus surgeons are able to perform heart operations that could not be attempted a few years ago.

The effects of low temperatures on human body processes are currently of great interest to many teams of scientific researchers. In a nonhibernating animal, such as man, when the temperature of the environment drops, there is no corresponding reduction in body temperature and metabolism. Indeed, the immediate effect is for the body to step up its metabolism to maintain its normal temperature.

Chilling Human Tissues

Dr. Charles P. Lyman, of Harvard's Museum of Comparative Zoology, is searching for the differences between the tissues of hibernators and non-hibernators. Why does human heart tissue stop beating if it is chilled too radically, while the hamster's heart beats on at near freezing temperatures? Early clues indicate that one difference may lie in the nerve endings. In the hamster the peripheral nerves resist cold.

Perhaps once again the study of animals and their behavior will provide man with answers to the mysteries of his own behavior.

Photo by Karl H. Maslowski from National Audubon Society

Jumping mouse, which covers 10 to 12 feet in leap, grows fat before hibernation, moves slowly. Hibernating mouse shown in photo took one breath every 15 minutes.

All photos from General Electric

Photomicrograph *(above)* shows man-made diamonds created under pressure. Catalyst metal covers freshly grown diamonds. Film is scraped off one crystal *(arrow)*.

Model of mold in which diamonds are created *(right)*. Top and bottom pieces are cone shaped pistons, press on graphite, held in chamber within center piece. Center piece acts as belt to keep graphite from expanding sideways as pistons press down.

HIGH PRESSURE

Squeezing Secrets from the Elements

By MICHAEL DADIN

FOUR years ago a group of scientists at the General Electric laboratories gathered around a maze of pipes, pistons, valves, and gauges to begin one of the most dramatic experiments in modern science—changing common carbon into sparkling diamonds.

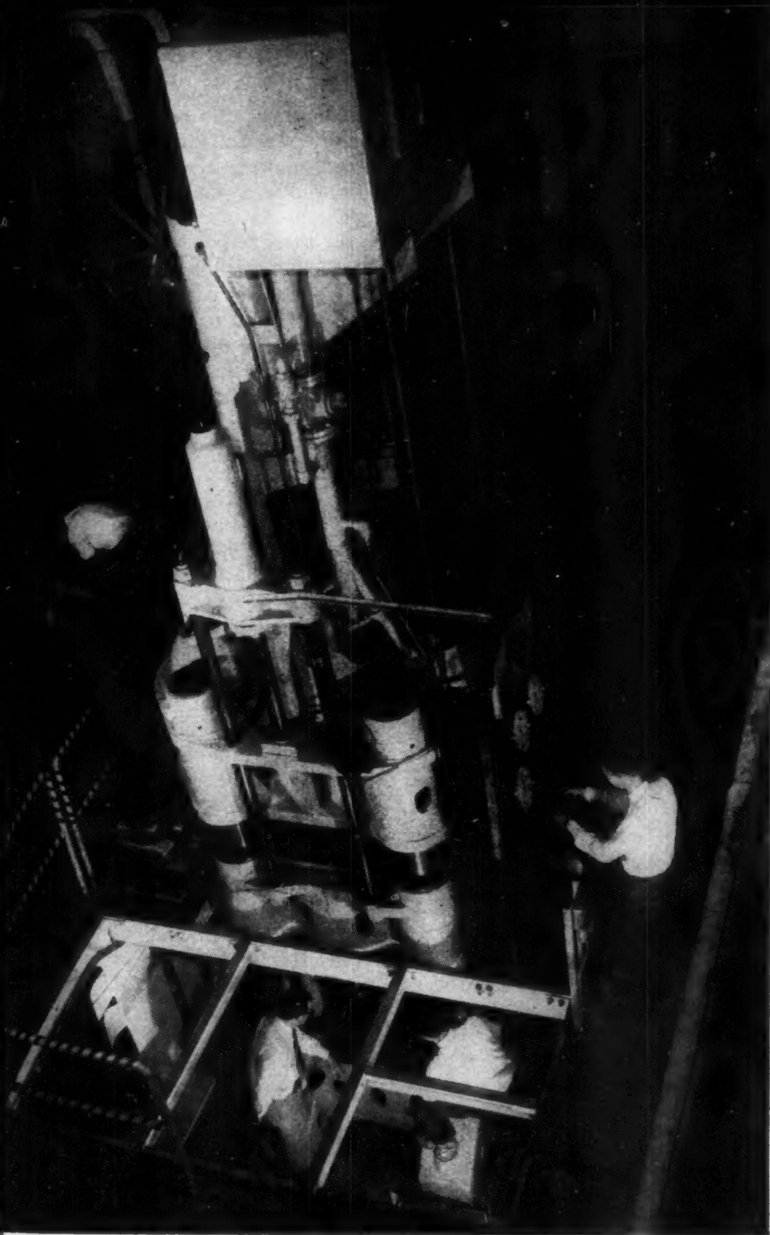
The maze of pipes was an ultrahigh pressure machine with which the scientists hoped to squeeze the carbon into diamond crystals. As the pressure was turned on, the scientists crouched behind concrete barriers, fearing an explosion. They knew their machine would create pressures greater than any dynamite blast.

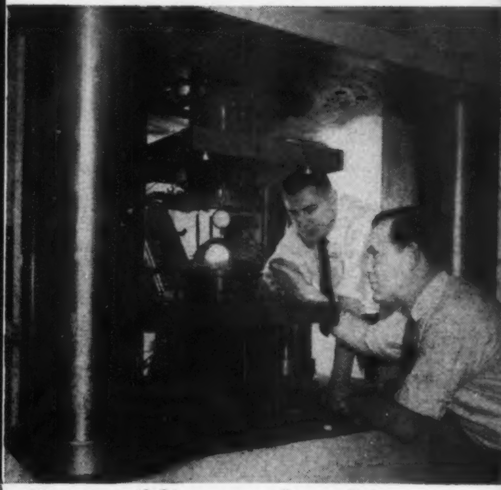
But the machine did not explode. Instead, it directed thousands of tons of pressure directly on the graphite (a form of carbon) powder in the pressure chamber. At the same time an electric current heated the graphite to 5,000 degrees F. When the machine was shut off the powder was examined under the microscope. The scientists found that they had achieved one of science's oldest dreams. They had changed graphite into diamond. The microscope revealed tiny diamond crystals mixed with some of the original graphite powder. *(See "Recipe for Diamond,"* Science World, *November 18, 1959.)*

The fact that diamond was only another form of the element carbon had long been known. Diamond cutters had learned many years ago that if a diamond was heated to 1,600 degrees F. it would take the form of a black powder, which was pure carbon. To change diamond into carbon was easy. But in trying to change carbon back into diamond scientists faced what seemed an insurmountable problem: They had to create extremely high pressures of the kind which exist only in the interior of the Earth, as well as high temperatures. They knew that all diamonds found in nature were formed millions of years ago inside the Earth by tremendous pressures and temperatures, and were later squeezed up through volcanic shafts to the surface of the Earth.

Pressures Inside Stars

To make the first artificial diamond, General Electric scientists had to create in the laboratory the tremendous pressures found 240 miles down toward the center of the Earth —about 1, 800,000 pounds per square inch. Imagine a weight of 1,800,000 pounds resting on one square inch of surface, if you can. This weight would push right through steel and rock. Such a pressure is over 100,000 times the pressure of the atmosphere at sea level. Scientists working with such high pressures usually measure them in terms of atmospheres.





Giant press (*left*) squeezes diamonds into life with pressure of 1.8 million lbs. per sq. in., or 100,000 atmospheres.

***Above:* Between piston and anvil (center of *photo*) fits mold shown on opposite page. Two G.E. scientists are at work in pit of giant press shown at the left.**

One atmosphere is about 14.7 pounds per square inch (psi), the pressure of the air at sea level. A hand-operated tire pump, for example, has a pressure of about two or three atmospheres, a hammer blow creates a pressure of about 5,000 atmospheres (momentarily), and a rifle bullet hits steel armor plate with 100,000 atmospheres pressure.

These are perhaps the highest pressures we can easily imagine, but they are still low compared to the pressures inside the Earth, the other planets and the stars. For example, the pressure where the Earth's core meets the Earth's mantle, 2,000 miles below the surface, is about 1,400,000 atmospheres, and the pressure at the very center of the Earth is 3,000,000 atmospheres. But the pressure in the interior of some stars may be as high as ten thousand million million (10^{16}) atmospheres. These figures are calculated from our knowledge of the mass of the stars—the greater the mass, the higher the pressure inside the star. The very dense stars, such as white dwarfs, probably contain the highest pressures in the universe.

Such pressures may seem fantastic to us, who live under one atmosphere of air pressure on the surface of the Earth. Scientists are just beginning to realize that the properties of matter, as we know them on the surface of the Earth, are the exception rather than the rule. The fact is that more than 99 per cent of the matter in the universe exists under pressures greater than 1,000 atmospheres. Since we know very little about the properties of matter at high pressure, this means that about 99 per cent of the universe has properties unknown to us.

New Forms of Elements

Scientists know that at high pressures many unusual phenomena occur: liquids freeze, gases turn into metals, and ice can be heated to the boiling point of water without melting. Many new forms of the elements are created—forms that have never been found in nature, such as Borazon, a material harder than diamond.

Borazon is a compound of the elements, boron and nitrogen. The name was created by using the "bor" from boron and "azon," a term which chemists use to indicate that a compound contains nitrogen. Borazon is a man-made material. It is not found in nature.

Before borazon was created, diamond was the hardest substance known, and it was often said that "only a diamond can scratch a diamond." But borazon scratches even the surface of diamonds, and can

stand temperatures twice as high as those that would consume a diamond. Like synthetic diamonds, borazon is made with pressures of more than a hundred thousand atmospheres. In both processes, high temperatures (about 5,000°F) are used, along with high pressure.

The effects of high pressure on materials were observed only during the past 50 years, mainly through the efforts of Dr. P. W. Bridgeman, a Harvard University scientist who spent a lifetime on high-pressure research. He was the first to design and build high-pressure machines which could develop 100,000 atmospheres in the laboratory.

In building such machines Dr. Bridgeman had to solve a difficult problem: Of what material should the pressure machine be built? Most materials break or flow like putty at high pressures. Even the hardest steel begins to give way at only 15,000 atmospheres pressure.

Eventually a man-made material, tungsten carbide, was used. This synthetic compound can withstand tremendous compressive force. The actual machine which Dr. Bridgeman designed used a piston of tungsten carbide inside a reinforced steel cylinder. The piston was forced forward by the pressure of a liquid.

What would happen when pressures rise to the point where even tungsten carbide gives way? The answer seems to lie in new, superstrong materials which can be made only under ultra-high pressures. Tungsten carbide, for example, is made under high pressure. Thus a machine with tungsten carbide pistons can make an even harder material, such as diamond or borazon. It is possible that a machine with diamond or borazon pistons could create even higher pressures, and make new and stronger materials. High-pressure research may literally pull itself up "by its own bootstraps."

Molecules Change Shape

All liquids or gases are frozen solid by pressures of 50,000 atmospheres or higher, except for helium, which would probably freeze only at 100,000 atmospheres. To understand why materials should change under pressure, we have to consider this question: What makes one material more compressible than another?

The most compressible materials are gases. According to Boyle's law, as the pressure increases, the volume decreases accordingly (if the temperature is kept constant). That is, doubling the pressure reduces the volume of a gas by half. Gases are easily compressed because the molecules in a gas are very loosely packed. They are free to move around in a great deal of empty space. The gas molecules bump into each other and against the walls of the vessel which contains them.

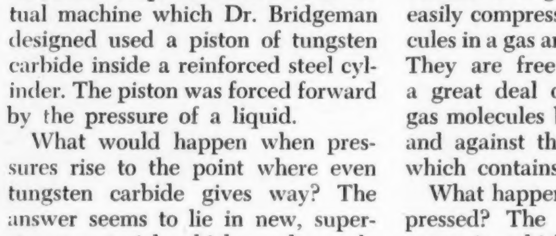
What happens when a gas is compressed? The molecules have less space in which to move about. A gas is readily compressed up to the point where the molecules are so tightly packed that they can no longer move freely. At that point the gas usually becomes a liquid.

To compress a liquid is more difficult than to compress a gas. In a liquid there is almost no empty space between the molecules. Applying extra pressure merely squeezes the molecules themselves, which resist with tremendous force.

Therefore, as the pressure on a liquid increases, the volume does not decrease very much. At that point when the molecules can no longer slide along each other as they do in a liquid, the material becomes solid.

As a material becomes solid, the molecules group themselves in cubes, pyramids, or more complicated geometric arrangements. In a metal the molecules would take the shape of a crystal. Some crystal shapes pack more closely than other shapes, just as you can pack more clothes into a suitcase if they are neatly folded than if you throw them in crumpled. In the same way, molecules arranged in cubic crystals could be packed more closely into a given space than molecules arranged in odd shaped crystals with protruding sides.

As the pressure is increased on a solid, the molecules or atoms rearrange themselves into different groups or crystals. Each successive group can be packed more closely than the previous group. The pressure forces the atoms into the tightest possible packing. For example, diamond and graphite are both forms



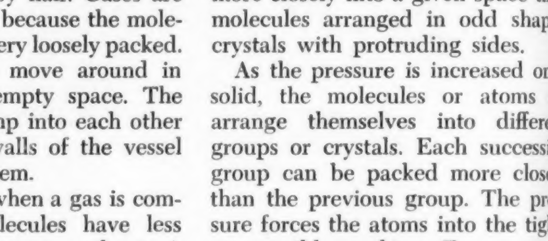


Diagram at left shows three states in which carbon can exist. Diagram at right shows areas of pressure-temperature research.

of carbon. But when graphite is compressed to over 100,000 atmospheres (and heated) the graphite atoms are rearranged into the crystals of a diamond. The diamond crystal is nothing more than an arrangement of carbon atoms which permits the closest possible packing.

In making artificial diamonds, General Electric scientists used a pinch of molten metal, such as chromium, to act as "atomic grease," allowing the carbon atoms to move more easily into their new arrangement.

Seven Kinds of Ice

As the pressure is increased, elements and compounds may go through several rearrangements of atoms or molecules before the arrangement for closest packing is achieved.

One unexpected laboratory discovery showed that there are seven kinds of ice which form under increasing pressure. At minus 22°F and 2,200 atmospheres pressure, ordinary ice crystals collapse into a new "kind" of ice, with a large decrease in volume. Because of the increased pressure, the melting point of this new ice is much higher. As the pressure is further increased, five more types of ice will form in succession. The last of these can be heated to the temperature of liquid solder without melting—provided it is under a pressure of 45,000 atmospheres.

The most compressible element is caesium, which loses about two-thirds of its volume at a pressure of 100,000 atmospheres. The least compressible element is carbon in the form of a diamond, which loses only two per cent of its volume at the same pressure.

Now suppose an element had its atoms packed together in the closest manner and the pressure was further increased. What would happen?

The pressure would begin squeezing the atoms themselves, forcing electrons out of their normal orbits. This means that at sufficiently high pressure, non-metals might actually show chemical properties of metals.

Theoretical calculations show that ammonia should change to a metal at somewhat over 200,000 atmospheres, and hydrogen should become a metal at about 400,000 atmospheres. It may not be long before such pressures are created in the laboratory. In fact, it may soon be necessary to create a new periodic table of elements—*valid only for elements under high pressures.*

At the interior of stars, the pressures are so great that it is hard to conceive of achieving them in the laboratory. At such pressures—several million atmospheres—all the electrons might be stripped from their nuclei. At even higher pressures the nuclei themselves might begin to fuse, creating nuclear fusion. Scientists have theorized that this is the process by which the sun creates its energy.

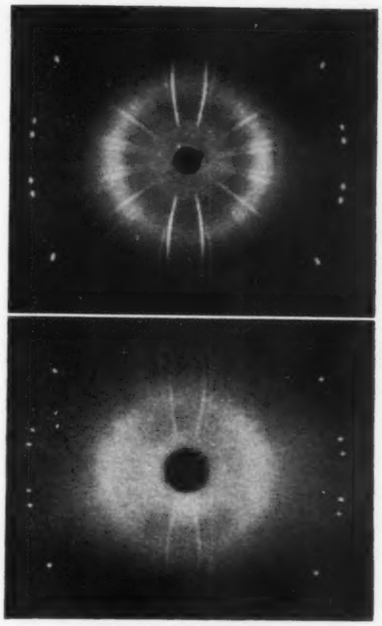
Studies in high pressures have also led to new theories about the interior of the Earth and other planets. For example, scientists had generally believed that the Earth's core was made up of iron or nickel because geological findings showed the core to be very dense.

However, geophysicists have recently suggested that the core may be composed of the same material as the Earth's mantle, a composition of iron and magnesium silicate called olivine (of which green garnets are composed). They suggest that the tremendous pressure at the bottom of the Earth's mantle (1,400,000 atmospheres) is enough to change the olivine from its normal state to a metallic substance three times as dense. This might give the impression that the core was made of a dense metal, such as nickel or iron.

Exploring Inside Earth

Support for this idea comes from the fact that the smallest planets, Mars and Mercury, appear not to have a core. Scientists theorize that since the planets are so small, the interior pressure is not high enough to create a dense core. In general, the larger the planet, the greater the pressure in its interior. Large planets such as Jupiter or Saturn may have cores of metallic hydrogen, since their internal pressure would be sufficiently high—about 800,000 atmospheres. Uranus and Neptune may have "ammonia" metal cores, created out of ammonia and methane at a pressure of 250,000 atmospheres.

Many of the Earth's minerals, such as garnets, have been synthesized in the high-pressure laboratory. By knowing the pressure and temperature required to make the minerals, we can deduce the process by which they were originally formed deep inside the Earth. For example, studies of one type of rock show that it could have been made only at a pressure of 30,000 atmospheres or more. This means that it had to originate at least 72 miles beneath the Earth's surface.



X-ray diffraction photos show arrangement of atoms in diamond crystal. Diffraction spectrum of natural diamond crystal (*bottom*) is identical with that of diamond crystal made in laboratory (*top*).

Perhaps 72 miles doesn't seem like a very great distance, but the deepest mine, the Champion Reef gold mine in India, is only two miles deep. And the deepest oil well ever drilled extends only four miles downward.

One of the most exciting scientific adventures under way is Project "Mohole," in which scientists plan to drill down five to ten miles through the Earth's crust and into the mantle *(see Sept. 9 issue).* Project Mohole will use a floating oil-drilling rig to drill under the ocean, where the Earth's crust is thinnest.

If the pressure and temperature do not melt the drill bit—and the project is successful—it will be the first time that man has penetrated beneath the Earth's crust. This may pave the way to exploring the interior of the Earth, enabling scientists to confirm in nature the phenomena revealed in the high-pressure laboratory.

Science in the news

Water on Venus

Does life exist on other planets besides the Earth?

A new clue to this problem was recently found by two Navy balloonists when they ascended 80,000 feet above the Earth and found water in the atmosphere of the planet Venus. This means that life, as we know it on Earth, *could* exist on Venus. Without water we could not expect to find life as we know it on Earth. All life on Earth lives in water or a water atmosphere.

The discovery of water vapor in Venus' atmosphere was made with a telescope and other instruments carried 15 miles into the stratosphere. The scientists had to reach that altitude in order to analyze Venus' atmosphere without interference from the Earth's atmosphere. At lower altitudes, the Earth's turbulent air would blur the view of the planet, and the water vapor in the Earth's atmosphere would be confused with any found on Venus.

The balloonists and their instruments rode in a sealed gondola, a metal sphere which dangled beneath the 15-story-high plastic bag (*see photos*). The balloon was released from the "Stratobowl," a dish-shaped valley in South Dakota. The stratobowl protects the balloon from winds while it is taking off.

(The balloon's landing on Earth was much rougher than the trip upwards. The gondola was carried down by parachute. When the gondola touched the Earth, strong gusts caught the parachute, which bounced the gondola along the ground for almost a mile.)

Three hours after take-off, the balloon had climbed to 80,000 feet and the balloonists set up their instruments: a telescope and a light-analyzing spectrometer. The telescope was aimed at Venus, 24,000,000 miles away. The spectrometer broke up the light from the planet into its different wavelengths, just as a prism breaks light into the colors of the rainbow. By analyzing these different wavelengths, the scientists were able to tell the compounds or elements in the planet's atmosphere.

Venus, about the same size as the Earth, has no light of its own. We see Venus by the sunlight reflected from her dense clouds. Some wavelengths of this light are absorbed by compounds and elements in the atmosphere above Venus' clouds. The spectrometer, which separates the light into its various wavelengths, thus indicates which wave lengths are missing. The light reflected from Venus was found to be missing the wavelengths absorbed by water. So the scientists concluded that water must be present in Venus' atmosphere.

Some years ago, carbon dioxide was found on Venus in the same way. There is probably several hundred times as much carbon dioxide on Venus as on Earth. Such experiments indicate that both the water vapor and the carbon dioxide exist above the clouds. The sunlight does not penetrate the 200-mile-thick cloud layer, but is reflected from its surface. It may be, however, that the clouds themselves are composed of water vapor, as are the clouds on Earth.

Plant and Animal Life on Venus

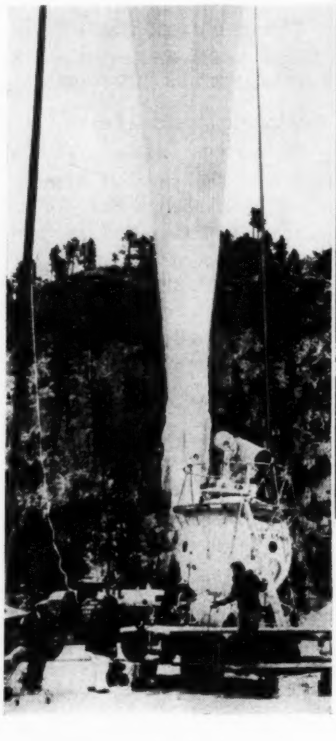
The spectrometer found almost no oxygen on Venus. This means that any life on Venus is probably not air-breathing, and so must be very different from life forms on Earth. Scientists believe that life forms which do not depend on oxygen can exist, and that such forms probably existed on Earth before green plants developed and released oxygen into the atmosphere.

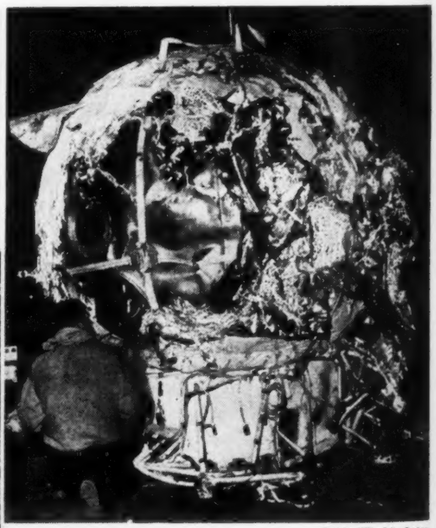
Green plants depend upon sunlight for their energy, and Venus' clouds allow very little light to pass through them. Scientists think that if the clouds were seen from below, on the surface of the planet, they would look dark gray. Therefore there are probably no green plants on Venus to create oxygen, and plants or animals similar to those on Earth do not exist.

But the biggest obstacle to life on Venus may be its temperature. Since the planet is closer to the sun than is the Earth, Venus is hotter than the Earth. The temperature on the surface of Venus has been measured by radio telescopes which can "see" through the clouds, and it is believed to be about 400°F. If this is true, it means that there is no evaporation cycle and rain never falls on Venus. Thus no lakes or oceans exist. The best guess is that Venus is probably a blistering desert.

Also, at that temperature chemical reactions involving carbon proceed at a very rapid and destructive rate. Since such carbon reactions are the basis of life, the chemical balance of living things on Earth could not be maintained.

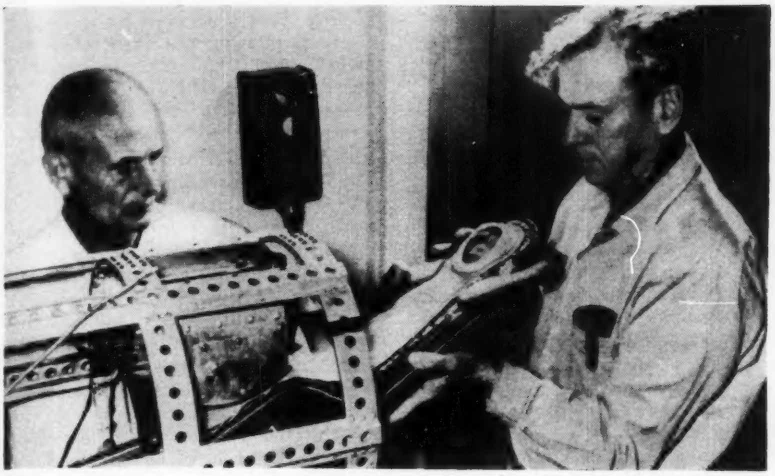
In the near future a rocket packed with scientific instruments may be sent to Venus to radio back definite answers to some of these questions.





Wide World photos

Ballooning in for a closer look at Venus. Navy Cmdr. Malcolm Ross and space scientist Charles Moore (*left*) prepare to climb into gondola slung below plastic balloon. Special telescope is mounted atop gondola. Photo above shows gondola after landing. Balloon had soared 15 miles. Scientific surveys were made of Venus. *(See news story above.)*



Sam the astronaut is placed into biopack container by Dr. Hugh Blodgett (*left*) and Dr. Lynn Brown. Rocket carried Sam to edge of space. Seven-pound rhesus monkey survived trip. Experimental data will pave way for man's flight into space.

NASA photos from UPI

Sam received his pre-flight training at the School of Aviation Medicine in Texas. Initials of school make up his name.

Antarctic for Science

The continent of Antarctica, a largely unexplored area bigger than the United States and Europe combined, is reserved exclusively for scientific research.

Twelve nations, including the United States and the Soviet Union, signed a treaty which forbids military activity in Antarctica, and encourages scientific observation in the colder-than-ice region.

The treaty bans nuclear explosions in Antarctica under a system of international inspection, and prohibits use of the region as a dumping ground for radioactive waste materials. The treaty applies to the continental ice shelf which is afloat (the little America base is on such a shelf), as well as the ice-covered land portion.

Before the treaty could be signed, the territorial claims of many nations had to be set aside. Among the nations claiming portions of the Antarctic are New Zealand, Argentina, Great Britain, Australia, Norway, Chile, and France. These claims are based on the nationality of the various explorers who have penetrated the continent. So far the U. S. has not claimed any territory in Antarctica, although U. S. scientists have explored more land there than the scientists of any other nation. Several nations, including the U. S. and Russia, maintain permanent scientific camps in Antarctica today.

Antarctica presents scientists with many challenging research projects. For example, meteorologists have found the region to be a vast "weather factory." Air and ocean currents there affect all other areas of the globe.

Mining engineers have found large seams of coal beneath the ice, and other valuable minerals may also lie there. However, it would be difficult to mine them since thousands of feet of ice would have to be cut through.

Antarctica may also become an international "airport" for space travel. Scientists have discovered that the belt of radioactivity which surrounds the Earth at high altitudes becomes very thin near the Earth's poles. The poles may be the only place where space travelers could depart and land without passing through dangerous radiation.

Another use for Antarctica may be as a giant deep-freezer for the rest of the world. Surplus food could be stored in Antarctica and defrosted when needed by hungry nations. Keeping the food cold would be no problem. The average winter temperature is minus 60 degrees Fahrenheit, and in the summer the temperature rises to 30 degrees F., barely to the melting point. One member of the Navy's 1955 expedition, ate some bread found in a food cache another exploring expedition had left behind 50 years before. His comment: "It was a little dry, but it tasted fine."

The great unexplored continent also poses many unanswered questions: Is the ice cap breaking up and melting faster than it is being restored through snowfall? If so, the oceans of the world may rise to the point where they will flood most of the world's land area. But this problem may not become acute for another 500,000 years.

Scientists are also wondering whether land bridges existed in past ages between Antarctica and other continents. If so, animals and plants may have passed from one continent to another. Such knowledge might change our ideas about evolution of the species.

Sam the Astronaut

At 11:15 a.m., December 4, a Little Joe rocket carried into space an astronaut sealed in a capsule. The hero of this venture into the unknown: Sam, a seven-pound rhesus monkey.

His entire trip lasted only 13 minutes and ended in the Atlantic about 200 miles from the launching site at Wallops Island, Va. Due to high seas, the Navy had difficulty retrieving and opening the capsule after its return to Earth. Seven hours after the launching the National Aeronautics and Space Administration reported: "Sam is alive, kicking and happy."

The purpose of Sam's flight was to test the pilot's emergency escape mechanism at high altitudes. This system is designed to save the astronaut in case anything goes wrong during the space shot. It consists of a small rocket which separates capsule from carrier.

Sam's job was to perform some simple operations during various stages of the flight, to determine his ability to do the work under conditions of weightlessness and high acceleration.

The monkey astronaut received his training at the School of Aviation Medicine (the initials make up his name) at Brooks Air Force Base in Texas. He was trained to move a lever similar to an airplane stick as a small light flashed in his capsule. As we went to press the flight data had not yet been analyzed. *Science World* will report the findings in a future issue.

Packed into a 100-pound "biopack container," Sam was then strapped in the place to be occupied by a human astronaut. He was outfitted in a form-fitting couch and space suit (*see photos*).

Science in the news

His body was perpendicular to the direction of motion, as will be the Mercury astronauts.

Sam was fitted with special measuring devices. One went around his eyes. It measured his disorientation and dizziness by picking up electrical impulses from his eye muscles and relaying them to a recorder. Other instruments measured the monkey's heart activity and breathing rate. As the capsule arched through the top of its trajectory, Sam went through three minutes of weightlessness. He endured forces up to 19 times the tug of gravity.

The outside of Sam's container had attached to it various biological specimens—rat nerve cells, molds, barley seeds, bacteria cultures, and cell-tissue cultures. Scientists hope to find out how radiation affected their life, mutation rate, appearance, and ability to reproduce.

Sam, nonchalant about his trip, was hungry and lively, reported Commander Joseph Sahaj, the first man to see the monkey after its recovery from the ocean by the destroyer *Brodie*.

Life on Mars—Illusion

Astronomers who believe that the green blotches on the planet Mars are plant life may be the victims of an optical illusion.

Mars, which has seasons just as does the Earth, is basically red-orange in color. Some scientists have reported that the green areas seemed to appear along with the arrival of the Martian spring. These green areas also seemed to turn to brown during the Martian fall. Such observations have led some scientists to conclude that the green areas are vegetation, whose color changes with the seasons, just as plant life on Earth does.

However, according to Professor Ingeborg Schmidt, of Indiana University, the color changes may be only an optical illusion. The "green" may really be a grey, which only *appears* green when seen next to the orange color of the rest of the planet. This illusion, where one color seems to change when brought into close contrast with another color, is a well-known psychological phenomenon.

To prove her point, Professor Schmidt projected a slide showing gray circles on an orange background. The grey circles appeared greenish. When the slide was thrown slightly out of focus, the green effect was more pronounced. Similarly, since most of Mars is orange in color, any dark areas would look green in contrast. Any blurring of the view caused by the Earth's atmosphere would only add to the effect.

The fact that the color changes coincide with the Martian seasons may be due to changes in the Martian atmosphere, and may not be the result of seasonal changes in plant life.

Brain Size

Man's ancestor never had a tail, and the size of his brain was not a measure of his intelligence.

These two statements, which are contrary to popular conceptions, were made at a panel discussion at the University of Chicago during celebrations of Charles Darwin's Centennial.

Dr. L. S. B. Leakey, British anthropologist who recently found a fossil skull in Kenya, believed to be that of the first true man, said no evidence was ever found to show that any of man's ancestors had a tail.

He said that the coccyx, sometimes referred to as "vestigial tail," shows that the vertebral column in man simply did not develop into a tail as it did in apes and monkeys.

Dr. Leakey also emphasized that not the size but the shape of the brain reflects intelligence.

"Size, except when taken in relation to the total body weight of the creature, is not important at all," he said. "Neanderthal man had a larger brain than any other man, and today Eskimos have the largest brain and Japanese the smallest, which does not reflect their relative intelligence," he explained.

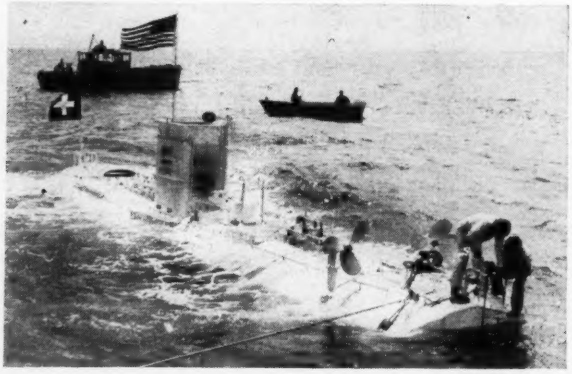
"There is no reason to believe at all that because, shall we say, Australopithecus man of South Africa had a brain about the size of that of a gorilla, that his ability in the use of his brain was of the same order. He could have had a brain of the same size but of a much greater complexity in its cortex."

How Radiation Kills

One way in which radiation kills has been demonstrated by two New York University scientists.

This information suggests that means may be found to decrease the deadliness of the rays and perhaps to undo the damage they inflict. This knowledge could then lead to future defenses against radiation from fallout or atomic bombing.

Dr. Evelyn Slobodian, Martin Fleisher and Dr. Sidney Rubenfeld, of the department of radiology at the NYU-Bellevue Medical Center, have demonstrated that radiation knocks a hydrogen atom off a water molecule



Wide World photo

Man's deepest dive was made when Bathyscaph Trieste plunged 18,600 feet in Marianas Trench in Pacific on U.S. Navy research project. Trieste consists of steel float and steel gondola for observers. To rise, divers dump steel shot—10 tons! Float is buoyed up by 28,000 gallons of gasoline.

Wide World photo

Photo of ocean floor was made through 8-inch-thick plastic port as Trieste's gondola lay close to bottom at 18,600 ft. Limit of visibility is about 50 feet. Gondola has three-and-a-half-inch steel walls to withstand pressure at bottom, and is designed to reach a maximum depth of 30,000 feet.

and that the remaining hydroxyl radical then reacts with a key enzyme to make it inactive and functionally useless.

The enzyme which proved vulnerable to the rays is ribonuclease, or RNase. This enzyme acts on the giant molecules called ribonucleic acids. When RNase ceases to function, these molecules can no longer be broken down, and the delicate balance between thousands of reactions which make up life chemistry may be altered.

This discovery might also explain a major mystery of life—the problem of mutation or changes in the genes, and the role played by radiation in the cause and treatment of cancer.

Caterpillar Poison

Bacteriological warfare has been declared against the caterpillar. A poisonous compound which paralyzes caterpillar larvae has been produced from bacteria.

The bacteria, brought from Japan, has been known for the last 50 years. It recently has been under investigation in Canada, the United States, France, and Great Britain.

Dr. T. A. Angus, head of the Insect Pathology Research Institute of the Canadian Department of Agriculture, headed the research team which found that the bacteria produced a spore and crystal formation which is poisonous to caterpillar larvae.

The next problem was to find a way of growing the poison in an artificial culture medium. It was necessary to find a medium which would permit the poison to be extracted in a form usable as a spray or dust. This was accomplished.

The poison differs from other insecticides by killing only a specific insect. Other insecticides kill both helpful and harmful insects.

Algae Flavor Bland

Scientists can now burn the bad taste out of algae. Algae is under study as a quick-growing food for manned space flight. But one drawback has been its taste—reported to be similar to that of tea leaves.

Dr. Romney H. Lowry, a scientist at the Boeing Airplane Company in Seattle, Wash., has greatly improved the palatability of this potential space food. He exposes it to more light than is necessary for growth. This has the effect of stopping the photosynthesis process, removing the green chlorophyll. Thus it leaves the plant food white instead of green. Removing the chlorophyll also removes much of the undesirable taste. This treatment of algae is relatively simple.

Chlorophyll constitutes between five and six per cent of the content of algae, a considerable amount, he explained. For comparison, it has been estimated that spinach contains less than one per cent.

Bleached algae can be more easily seasoned and flavored, because the white form has a bland taste. The plant food itself is still the most popular food being considered for space flights.

It was doubted whether any nutritional loss would occur as a result of the bleaching technique.

New Arctic "Island"

A huge underwater island rising from the floor of the Arctic Ocean was recently discovered by U. S. scientists. The island is about 500 miles north of the tip of Siberia, where the depth of the ocean is about 9,000 feet. The "island" rises from this depth to within 900 feet of the surface. It was charted by four scientists from Columbia University's Lamont Geological Observatory, manning a scientific station aboard a drifting ice floe.

Such ice floes and their scientific stations move at random with wind and current, and are carried back and forth over the ocean. This makes it possible for scientists aboard the station to map features on the bottom, by echo sounding. This method measures the time it takes for a sound wave to echo back from the ocean floor.

The top of the island is flat like a plateau, and its area is estimated to be about 14,000 square miles (about the size of Vermont and Connecticut). It is similar to the great tableland in the western U. S.

The island may have been discovered earlier by the submarine *Nautilus* during its journey under the North Pole. The *Nautilus* reported a submerged "mountain range" in the same area.

Underwater photographs showed many forms of marine life on top of the island, such as sponges, shrimp, sea anemones, and small fish. The surrounding ocean bed, 8,000 feet deeper than the plateau, showed almost no signs of marine life. Also found were fossils of clams and snails estimated to have been dead more than 10,000 years.

Force-Feeding Trees

Force-feeding forest trees may turn out to be a promising method for getting better growth, reports H. A. Fowells, U. S. Forest Service.

Little is known about nutrient requirements of most trees. Loblolly pine studies show they will respond to an increased supply of nutrients.

Mr. Fowells indicated that a more thorough examination of the growth needs of other trees is needed.

Science Fair time is just around the corner. Why not use this news item as the basis for a science project?

UPI photo

***Atomic Antler Pile*—Deer antlers are under study by scientists measuring radioactive strontium fallout. Strontium is deposited in calcium of bones. Quick-growing antlers, which bud each spring and drop off in winter, provide yearly measurements. Antlers collected in 1957 had 11 times amount of strontium found in 1952 antlers.**

today's scientists

SELMAN A. WAKSMAN
Man Against Microbes

He led armies of microbes into battle in the long war against infection—after a lifetime of research

Photo by E. J. Higgins from Rutgers University

A PINCH of soil contained the ingredient that opened up a whole new field of antibiotics. Behind the pinch of soil is a tale of painstaking research.

The man who directed this research was Dr. Selman A. Waksman, Nobel Prize winner.

Born in a bleak village in the Russian Ukraine, in 1888, he had little opportunity to get a higher education. In 1910 he migrated to the United States at the age of 22.

Upon his arrival, he stayed with relatives in Metuchen, New Jersey, a few miles from Rutgers University. Since his first ambition was to become a physician, he applied for admission to the College of Physicians and Surgeons of Columbia University. However, he soon changed his mind.

He became acquainted with another Russian immigrant, Dr. Jacob Lipman, then head of the New Jersey Agricultural Experiment Station at Rutgers University. Lipman's interest in the microorganisms of the soil "rubbed off" on young Waksman. This was the turning point in his career. Waksman was to spend the rest of his life at Rutgers, studying the microbes that inhabit the soil.

College Freshman at 22

He enrolled as a freshman at Rutgers and, with the aid of a scholarship, worked his way through college. By the time he was in his senior year he was doing research under Dr. Lipman's direction, studying the actinomycetes, a group of microorganisms related to both the bacteria and fungi. These organisms eventually led him to the discovery of the antibiotic streptomycin.

In 1915 Dr. Waksman became a naturalized citizen, and in the same year he received his B.S. degree. A year later, he obtained his M.S. from Rutgers. Two years later he was awarded his Ph.D. degree by The University of California.

In 1918 he was back at Rutgers teaching soil microbiology. In 1943, he became professor of microbiology.

In addition to teaching, Dr. Waksman worked as a microbiologist at the New Jersey Agricultural Experiment Station. He studied the problem of soil conservation, and his research was focused on microbe inhabitants of the soil. Days, weeks, months, and years passed as he patiently observed the battle of microbe vs. microbe being fought in the arena of a test tube of soil. He became an expert on humus, the material formed by the decomposition of vegetable or animal matter in or on the soil. His research enabled him to show farmers how they could increase soil fertility.

The Microbe Battle for Survival

Exactly how do these microbes affect soil? How do they affect each other? What effects, if any, do these microbes have on man? These questions intrigued Dr. Waksman.

Under his microscope a tiny pinch of soil showed up as a battleground where microbe fought microbe in a struggle for survival. Flourishing populations of bacteria wiped out other bacteria. Dr. Waksman knew that some of these changes were due to fluctuations in temperature and inadequate food supplies. He knew, too, that some types of microbes feed more rapidly than other types. They have a faster rate of metabolism, enabling them to use up the available food supply. Or a species might reproduce at a faster rate, consuming available food. But all the evidence pointed to still another way in which one type of microbe destroyed another type.

We know now that some microbes have the ability to destroy other microbes by producing chemicals which act as poisons. But when Dr. Waksman was studying soils, this weapon of "micro-warfare" was unknown.

By this time World War II had come upon us and new weapons against infection were needed desperately. Penicillin was coming into widespread use. But as penicillin wiped out micropopulations, other micropopulations, relieved of competition, grew alarmingly to fill the field left vacant by the casualties. Other antibiotics were urgently needed. Dr. Waksman and his staff looked to the soil for new life-saving antibiotics. His procedure was to feed disease germs to soil microbes and then watch any action that might take place.

Unlike the chance discovery of penicillin, the finding of streptomycin was not accidental. Like most scientific discoveries, it took years of research.

Dr. Waksman had observed previously that actinomycetes won out against all other soil microbes in the battle to survive under unfavorable conditions. Might these same microbes destroy germs in man?

10,000 Microorganisms Tested

Four years passed as Dr. Waksman and his assistants experimented with thousands of strains of actinomycetes. These were found in soil samples gathered in various countries. The goal: to find an antibiotic which would destroy germs that were not attacked by penicillin. At the same time, the antibiotic had to be one that would not have a harmful effect on the human body.

About 10,000 microorganisms were isolated and tested. Only about 10 per cent had the ability to inhibit the growth of bacteria. More research indicated that only 10 chemical compounds identified with these bacteria had the properties the investigators were seeking.

(Continued on page 29)

tomorrow's scientists

Project: Theoretical Prevention of Aeroembolism

Student: **William S. Barry**
The Bronx High School of Science
Bronx, New York
Science Achievement Awards Winner

Teacher: **Dr. Jerome Metzner**

William S. Barry plans to enter the field of Aviation Medicine as a physician. His first contribution to this new and exciting field is a report dealing with the theoretical prevention of Aeroembolism.

Foreword

I formulated this theory for the prevention of Aeroembolism, with the detailed scientific basis to support it, as given in this report, in the belief that high altitude flying will be aided through its use.

Definition

Aeroembolism or Decompression Sickness is the formation of gas bubbles in the fluids and tissues of the body, as a result of exposure to lower atmospheric pressures. This results in pain, paralysis, visual defects, and other effects.

Etiology

The air (dry) which we breathe consists of the following percentages of gases at all altitudes considered:

Constituent Gases	Mol. Fraction Per Cent
Nitrogen	78.09
Oxygen	20.95
Argon	0.93
Carbon Dioxide	0.93
Neon	1.8×10^{-3}
Helium	5.24×10^{-4}
Krypton	1.0×10^{-4}
Hydrogen	5.0×10^{-5}
Xenon	8.0×10^{-6}
Ozone	1.0×10^{-6}
Radon	6.0×10^{-18}

From this air 9/20 of the oxygen we take in is carried in the blood and bound to hemoglobin, while 1/20 is in physical solution.

Of the above gases the main constituents absorbed by 100 c.c. of blood at sea level are approximately 1.5 c.c. of nitrogen, 0.36 c.c. of oxygen, and 2.7 c.c. of carbon dioxide. Oxygen and carbon dioxide have greater amounts in loose chemical combinations. As for nitrogen, about five to six times as much nitrogen as that carried in the blood is absorbed by body fat. The total nitrogen in the body is approximately 26 times the amount in the blood. These gases, plus water vapor, which contributes to the bubble formation, form the following gas pressure in the capillary and venous blood.

Gas	Pressure
Nitrogen	573 mm Hg
Carbon Dioxide	47 mm Hg
Water Vapor	47 mm Hg
Oxygen	40 mm Hg (variable)
	707 mm Hg

As long as the pressure is 707 mm Hg the respective gases will remain in solution. However, at an external pressure below 707 mm Hg formation of gas bubbles may be anticipated. The problem is to maintain the nitrogen pressure at a sufficiently low level, so that the bubble formation will not be independent of rapid ascent.

During ascent the following occurs when the partial pressure of body nitrogen is above that of nitrogen in the lungs. The tissues of the body become supersaturated. When this occurs the body tends to rid itself of its excess nitrogen by giving off the nitrogen in the blood to the lungs and from the body tissues into the blood.

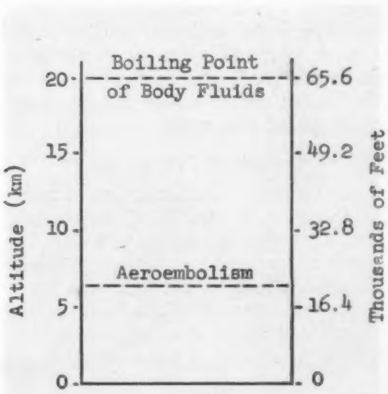
When the ascent rate becomes greater than the rate of body elimination of excess nitrogen, this gas will come out of solution and form bubbles to which are added carbon dioxide, oxygen and water vapor from the surrounding tissues and blood. Nitrogen bubbles appear at an ascent exceeding 78 ft/min. The most likely site for this occurence is in the parts of the body which have the highest fat content and the poorest blood supply.

Symptoms

The formation of gases in the body causes the following symptoms in the order of occurrence: pains in the joints, sensations of hot and cold, itching, violent muscular contractions, burning sensations, and coughing.

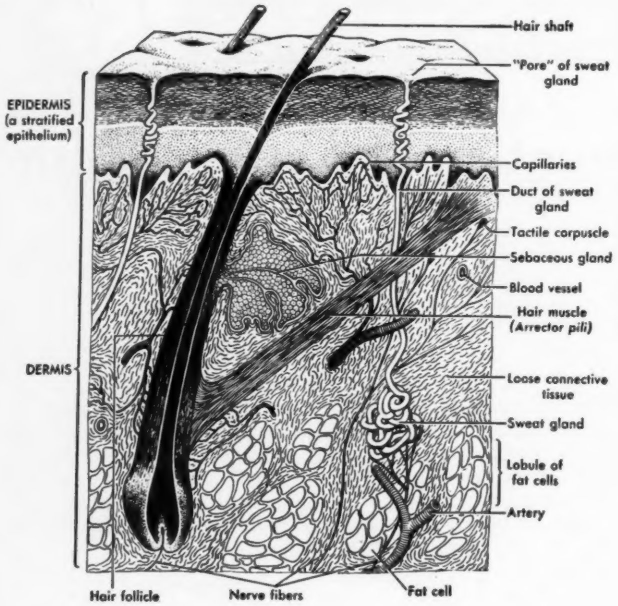
Present Treatment

The prevention of Aeroembolism has resolved itself around two measures: (1) the sustaining of pressure around the body, and (2) the maintaining of a low nitrogen pressure in the body. Of the first measure, various means such as partial pressure suits and full pressure suits have been developed in addition to the pressurized cabin.



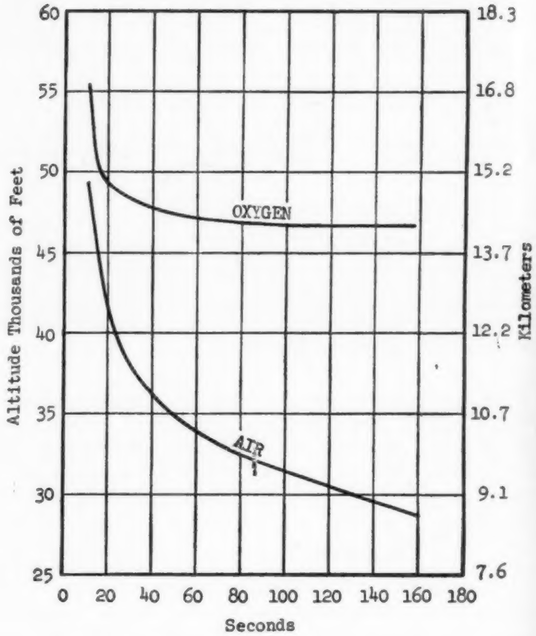
Graph shows that boiling point of body fluids at 37° C. ranges from 23,000 ft. for open blood vessels to 65,000 feet.

tomorrow's scientists



Life, by Simpson, Pittendrigh, Tiffany (Harcourt, Brace)

Human skin consists of many distinct tissues. The outermost cells of epithelium are constantly being worn away. At base of epithelium is generative layer (stippled) making new cells.



Graph indicates average time of consciousness when breathing air or oxygen, following sudden loss of cabin pressure. Notice various changes which occur as the altitude increases.

The problem with the partial pressure suit is that it cannot be worn for long periods of time. The full pressure suit, while it is effective, is clumsy and immobilizes the wearer. As for the pressurized cabin, it is heavy and hard to pressurize. A sudden leakage may cause explosive decompression sickness.

The second measure is the substitution of the soluble nitrogen gas with a less soluble gas which could be inhaled (the gases which have been tried are oxygen and helium). While this to a great extent prevents Aeroembolism, there must be a period of inhalation of the gases which limits the combat-readiness of the crew.

Proposed Prevention

My proposed treatment may be used as a means to prevent Aeroembolism semi-naturally. Briefly, by opening the pores and/or mild sweating, nitrogen elimination may be accomplished.

The following gives the basis for the theory and more detailed information on the prevention of Aeroembolism.

Sweat

Sweat consists partly of the watery contents of the blood. It is separated from the blood by the sweat glands and eliminated in drops of fluid on the surface of the skin. The armpits, palms, and soles are well equipped with these sweat openings. It has been estimated that there are from 2,736 to 3,528 to the square inch of sweat pores in these areas. The neck and back have about 417 to the square inch. The entire number of sweat pores of the body is estimated at 2,381,428, which provides a total opening of about eight square inches.

These sweat pores which provide eight square inches of opening, plus the normal respiratory openings (nose and mouth), provide a large area for the elimination of nitrogen from the body. By use of diaphoretic chemicals (chemicals which can increase perspiration), not only will nitrogen and water vapor be eliminated, but some of these chemicals will also increase the amount of blood flow to the skin. This provides both improved nutrition and increased circulation, which provides less chance of Aeroembolism in the skin, the area normally affected.

As the pressure decreases, the eight square inches and respiratory openings would provide the necessary requirement for the elimination of nitrogen before its formation into bubbles in the blood and tissues of the body. The gases dissolved in the tissues would partially go into the blood and out the lungs and gland openings. The rest of the gases near the glands possibly will be eliminated directly through the pores.

Water vapor and other gases will also be eliminated. Since nitrogen elimination is the main problem, the gas bubbles are therefore referred to as nitrogen gas in this report. In theory, this would provide a semi-natural prevention against Aeroembolism, since the nitrogen gas elimination would be proportional to the rate of ascent and its absorption to the rate of descent.

The evaporative loss is proportional to the water vapor pressure difference between skin and atmosphere as given in the equation $Q_e = f_s h_e (p_s - p_w)$.

Q_e = quantity of evaporative loss.

f_s = wetter fraction of body surface.

h_e = heat transfer coefficient by evaporation.

P_s = vapor pressure at skin surface mm. Hg).

P_w = atmospheric vapor pressure.

The variables f_s and p_s are determined by the environmental conditions and physiological state. The "Dip Point" as

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today's scientists

Aeroembolism

(Continued from page 22)

given by the Gagge for nude subjects $f_s.H_e$ has a value of 2.85 Kg-cal/m^2/hr/mm.Hg. This is defined as the condition for f_s to equal to 1.0 (completely wet skin with full sweating). When sweating ceases and insensible perspiration supplies the only water for vaporization at lower temperatures, evaporative heat loss is equivalent with f_s equaling 0.10 in the above equation.

Sweat ordinarily contains 0.22 to 0.81 per cent of ash, and 0.043 to 0.084 per cent of nitrogen, mainly in the form of urea of which there is 0.21 per cent, and 0.285 per cent of NaCl. The daily cutaneous excretion of nitrogen is from 0.3 to 1.8 grams. Even during rest the sweat averages 0.07 grams of nitrogen per day. This is considerably increased in proportion to muscular labor, to 0.22 grams of nitrogen per hour.

These statistics demonstrate that nitrogen is eliminated by means of sweating even though there is no difference of pressure. Sweat stimulated by a diaphoretic chemical, such as Pilocarpine, will give the following changes in the constituents of a normal individual's sweat: 0.051 to 0.085 per cent of nitrogen and 0.26 to 0.31 per cent of ash. Three liters of sweat would therefore remove about 2.5 grams of nitrogen.

In Nephritis (inflammation of the kidneys, especially Bright's disease) the nitrogen content may be much higher, so that the three liters could remove eight grams of nitrogen. This indicates how effectively the kidneys may be relieved by diaphoresis.

The secretion of sweat may be increased by:

(1) Stimulating the secretory structure
 A. Peripherally (Pilocarpine)
 B. The sweating center (camphor, ammonium acetate)

(2) Increasing the cutaneous circulation
 A. Locally (mustard, external heat)
 B. Through the vasomotor center (internal heat, alcohol, salicylates, acetanilide)

Anhydratics

Anhydratics (chemicals that cause dehydration) may be used as a means to control the effects of Diaphoretics. They may possibly be combined with Diaphoretics, to give the desired effects for the prevention of Aeroembolism.

To prove and test my theory, I built an altitude testing chamber. Scale drawings of this chamber are shown in the illustrations below. It is made of 5/8-inch plywood with a control panel, mounting switches, and indicating lights to control the lighting, 120-volt and 10-volt outlets in the chamber. Rubber gasket sealed plastic windows, 1/2 inch thick, provide a viewing area of 136 square inches. Vacuum is formed by a motor-powered Cenco Vacuum Pump. The altitude chamber and vacuum pump are mounted on a movable metal carriage and may easily be detached, if necessary. Altitude is measured by a 0-760 mm. Hg vacuum gauge. An altitude of 34,000 feet and a rate of climb of 21,000 feet per minute have been obtained during testing.

At the present time I am perfecting a mechanism (which I have already built) which when used in connection with the altitude testing chamber will simulate the Aeroembolism cycle that would occur in the human body during ascent and descent. This would be used to study Aeroembolism outside the human body.

Conclusion

The prevention and treatment of Aeroembolism would be as follows:

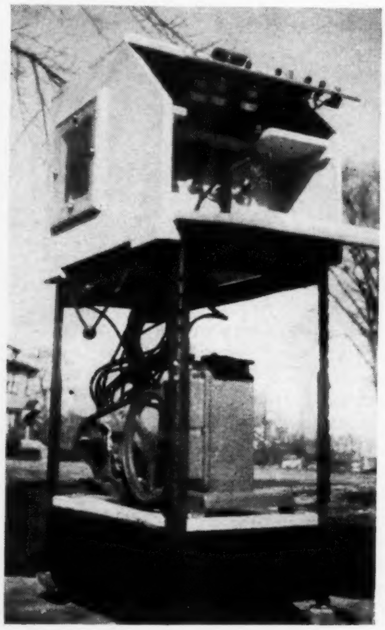
A preparation of either solely diaphoretic chemicals or a combination of both diaphoretic and anhydratic chemicals would provide sufficient effects such as increased cutaneous circulation and openings through the sweat glands. This would provide a sufficient area for the elimination of nitrogen. Consideration must be taken so as not to cause ill effects, such as fatigue and distractions.

As sweating may become disturbing, sweat need not be secreted to aid in elimination of nitrogen and other gases. In this case, sole means would be through the open pores.

A dose of the above medication would be given to the aircraft crew preparatory to flight so as to render sufficient time for the medicine to take effect. Upon the ascent of the aircraft, the gaseous elimination initiated by both the medication and pressure differences serve to provide a lowering of nitrogen pressure in the body—proportional to that of the outside air.

This treatment would be limited to about 50,000 ft. (15.2 km) at which point there is lack of enough intrapulmonary pressure to prevent hypoxic hypoxemia.

In the preceding pages the theory for a semi-natural method of preventing Aeroembolism has been presented in the hope that its successful use may provide immediate safety in the air for both crew and passengers of high altitude flying aircraft.



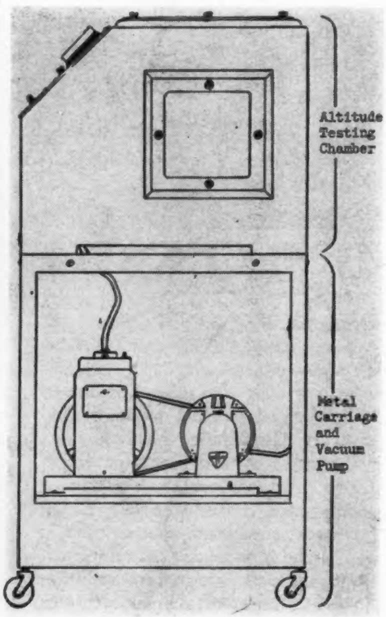


Photo at left shows movable metal carriage with pump on it and altitude chamber on top. Electrical connections are in rear. Diagram at the right shows a side view of the altitude testing chamber. Scale: four millimeters are equal to one inch.

Meeting the Test

Interpreting Relationships in Graphs

By THEODORE BENJAMIN

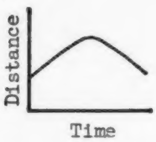
TO PUT his data into the form of a graph helps the scientist to see the precise relationships that exist between things being studied. In fact, to the scientist graphs are worth many, many words. The ability to interpret graphs is something all students of science must develop. The modern test or examination is quite likely to include graph interpretation questions.

If you know how to approach questions of this kind they will give you little trouble. First, make sure you see exactly what variables are presented in the graph. Second, establish how each variable changes as the other variable changes. Third, recall whatever you know about how these variables have been related in other situations. Fourth, keep in mind those variables which produce straight lines rather than curve relationships. For example, you will never find a straight line relationship between any two variables which "snowball" in relation to each other.

I. On line to left of questions 1 to 5 indicate the appropriate graph. Questions relate to following graphs:

A

B



C

D

___1. A ball is released from the top of an inclined plane. Which graph most nearly represents the relationship between distance traveled and time?

___2. A man walks away from a plane mirror at a uniform velocity. Which graph most nearly represents the distance of his image from him with respect to time?

___3. A man walks toward a plane mirror at a uniform velocity. Which graph most nearly represents the distance of his image from him with respect to time?

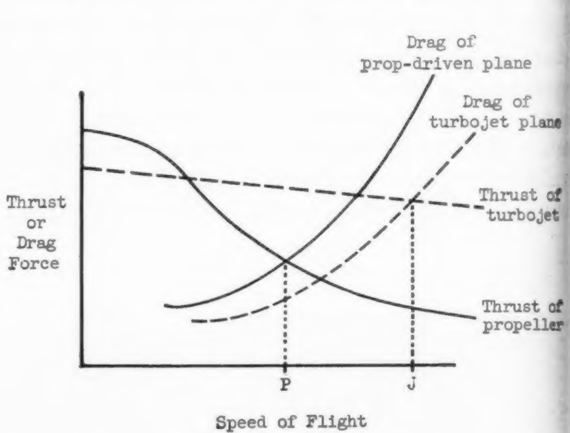
___4. A man leaves his home in the morning and, realizing that he has forgotten his office keys, returns to get them.

___5. A car starts from rest and accelerates uniformly. Which graph most nearly represents the relationship?

II. When data have been plotted, scientists gain another kind of help. Not only do proved facts stand out clearly, but the scientist also can improve the accuracy of his predictions of relationships not yet proved. Items 6 through 16 let you try your mind at this kind of problem.

On line to left of each statement indicate the appropriate answer.

Write A if statement is true according to graph.
Write B if statement is false according to graph.
Write C if statement cannot be answered from data.



___6. A propeller-driven plane can develop a greater thrust than a turbojet at low speeds.

___7. The efficiency of a turbojet is greater than that of a propeller-driven plane at high speeds.

___8. The speed represented by point P is that velocity at which the thrust of a propeller-driven plane equals the drag on the plane.

___9. Speed P is the maximum velocity a propeller-driven plane can develop.

___10. Speed J represents the lowest velocity at which a turbojet can sustain itself in the air.

___11. The maximum speed of a turbojet is approximately 1½ times that of the propeller-driven craft.

___12. Jet planes are better streamlined than propeller-driven planes.

___13. The thrust of a propeller-driven plane is approximately inversely proportionate to the speed.

___14. The thrust of a turbojet is nearly constant with increasing speed.

___15. Both planes can exceed speed J but the turbojet can go faster.

___16. The turbojet has lower efficiency than the propeller-driven plane at low altitude.

(Answers are on page 29)

The cars are safer... the roads are safer...

THE REST IS UP TO YOU!

You're in the driver's seat . . . but there's plenty of company riding along with you. Because, you see, to get behind that wheel you had to earn the confidence of a lot of people. Your parents, the parents of your friends, the authorities who issued your driver's license . . . all are confident that you are a safe, capable driver who uses mature judgment at all times.

There are others interested in helping you drive safely, too. Automotive engineers actually *design* safety into today's cars. You stop more surely with today's brakes, enjoy better all around visibility through Safety *Plate* Glass, ride on safer tires, and improved headlights make night driving safer for you. Traffic safety authorities contribute modern expressways, divided highways, overpasses and simplified traffic guidance systems. But with all of this help, the final responsibility is yours alone. Just practice courtesy, alertness, caution . . . and always treat the other driver as *you* would like to be treated. This will make you a safer driver, it will make driving more fun, *and* it will increase your chances of using the car more often.

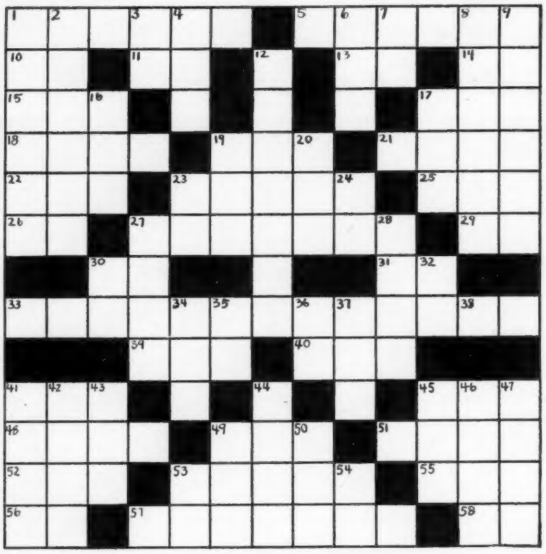
GENERAL MOTORS A CAR IS A BIG RESPONSIBILITY—SO HANDLE WITH CARE!

Earth Science

By Kenneth Trufant, Abington (Mass.) High School

★ Starred words refer to geology

Students are invited to submit original crossword puzzles for publication in *Science World*. Each puzzle should be built around one topic in science, such as astronomy, botany, geology, space, electronics, famous scientists, etc. Maximum about 50 words, of which at least 10 must be related to the theme. For each puzzle published we will pay $10. Entries must include symmetrical puzzle design, definitions, answers on separate sheets, design with answers filled in, and statement by student that the puzzle is original and his own work. Keep a copy as puzzles cannot be returned. Give name, address, school, and grade. Address Puzzle Editor, Science World, 33 West 42nd Street, New York 36, New York. Answers to this puzzle are on page 31.



ACROSS

* 1. Great fractures in the Earth's crust.
* 5. Light volcanic glass full of minute cavities.
10. Bone (*in Anatomy*).
11. An exclamation.
13. Rhenium (*chemical symbol*).
14. Either, ______; neither, nor.
15. Inflamed swelling of eyelid.
17. Also.
*18. Spot where subsurface water oozes.
19. A quick, smart blow.
*21. A bend produced in rock.
22. Man's name.
*23. Mountain range in Wyoming.
25. Born (used to introduce a maiden name).
26. Land Service (*abbr.*).
*27. Mount Elbert is the ______ peak in the Rockies.
28. These initials on a music score mean repeat.
30. Methyl (*chemical abbr.*).
31. House of Commons (*abbr.*).
*33. Changes in constitution of rocks.
39. Large wine cask.
40. To violate Divine law.
41. Lick up.
45. Used to be.
48. Sharp tools for felling trees.
*49. Drawing of the Earth's surface.
*51. Crystallized mineral silicate.
52. Very important person (*abbr.*).
*53. Particle of gold left in pan after washing.
55. Roman number X = ______.
56. Arsenic (*chemical symbol*).
*57. Causative agent of erosion in high altitudes.
58. Pierre is capital of this state (*abbr.*).

DOWN

* 1. Trace from past geological age.
2. Fall flowers.
3. Behold.
4. Article.
6. Grecian vase.
7. Objective case of I.
* 8. Tempered.
* 9. Land ______ __ by the action of water.
*12. Daily atmospheric phenomena.
16. Affirmative vote.
17. Two thousand pounds.
19. Region (*abbr.*).
20. Author of "The Raven."
23. 7th note in musical scale.
24. Halifax is the capital of ______ (*abbr.*).
*27. Factor in formation of igneous rock.
28. Slender.
*30. A land mass which projects conspicuously above its surroundings (*abbr.*).
32. Capital stock (*abbr.*).
*34. Type of sediment found beyond the sands in open seas.
35. Upon.
36. Postscript (*abbr.*).
37. His Imperial Majesty (*abbr.*).
*41. Fluid rock.
42. Earth revolves on its ______.
43. Vim, energy (*slang*).
*44. A soft mineral.
45. Clever humor.
46. Famous combat pilots.
*47. Disintegrated rock.
49. Family of extinct flightless birds.
50. Native Hawaiian food.
53. Chlorine (*chemical symbol*).
54. Egyptian sun god.

Project and Club News

Inventor of ARLIC

"If you want to set off a rocket, you put the rocket in this installation and it will fire it. Then it will guide it to wherever you want it to go. It's the same idea as they have at Cape Canaveral, except it's less costly."

Are these the words of a scientist? No! They come from Robert Langstroth, 17, of Newton, New Jersey. He had just won a $400 scholarship at the National 4-H Club Congress. What did he do to receive this award? He simply built an Automatic Radio Location Indication Computer (ARLIC for short).

His computing system took three years to build. It was made of parts taken from old radio and TV sets, an old electric sign, a used juke box, and materials Robert bought from an Army surplus store. Total cost: $300.

Robert is a senior at Newton High School. He is an amateur magician and a member of the Institute of Radio Engineers since he was 15.

Robert has taken ARLIC apart. As he explains: "Once you've built it, you've proved your point."

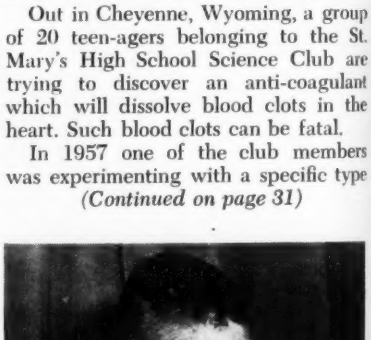
What will he do with the parts? Work on another project, of course.

Science Club Goal: Anti-coagulant

Out in Cheyenne, Wyoming, a group of 20 teen-agers belonging to the St. Mary's High School Science Club are trying to discover an anti-coagulant which will dissolve blood clots in the heart. Such blood clots can be fatal.

In 1957 one of the club members was experimenting with a specific type

(Continued on page 31)



Wide World photo

Robert Langstroth, inventor of ARLIC.

set up to prove

Man Against Microbes

(Continued from page 20)

These compounds were tested on animals. Out of these compounds came streptomycin. In 1944 Dr. Waksman and his assistants, Albert Schatz and Elizabeth Bugie, ~~completed~~ rigorous tests which proved that streptomycin had no delayed harmful effects on animal bodies. The discovery of streptomycin was announced to the world. It became the first drug ever to be used effectively against tuberculosis.

Dr. Waksman's research had been done with a small budget in cramped laboratory quarters. As soon as drug firms went into streptomycin production, he received royalties which approached $1,000,000 a year. But Dr. Waksman, like so many other dedicated scientists, took only five per cent of the royalties. His research patents were assigned to Rutgers University so that the money could be spent for additional research facilities.

On June 14, 1954, Dr. Waksman stood on the Rutgers University campus at New Brunswick, New Jersey, and saw the first result of his generosity: the opening of a $3,500,000 Institute of Microbiology—the first such institution for the exclusive study of microbes.

Hobbies: Research and Writing

Although Dr. Waksman seldom finds time for leisure, he does enjoy reading Byron, Poe, Pushkin, and Anatole France. He and his wife also enjoy attending the theatre and concerts.

Now past 70, Dr. Waksman is director of research of the Rutgers Research and Educational Foundation. He has written one of three planned volumes on microorganisms, and gives about six lectures a year in various parts of the world. His hobbies? Just what you would expect from a dedicated scientist: research and writing.

Among his many honors is the Nobel Prize in Physiology and Medicine, awarded in 1952 for his discovery of streptomycin. At the two hundredth anniversary of Princeton University he received an honorary degree for "leading armies of microbes into battle."

The battle continues. Thanks to men like Dr. Selman A. Waksman, the first breakthroughs have already been accomplished. But the war is not over—not by a long shot. And in laboratories around the world, new and more effective weapons are being sought.

Answers to Meeting the Test

(See page 26)

1. D; 2. B; 3. A; 4. C; 5. D; 6.A; 7. C; 8. A; 9. A; 10. B; 11. A; 12. A; 13. A; 14. A; 15. B; 16. C.

Brainteasers

Snoopy Bear

A man built a square house with four walls and a window in each wall. All of the windows faced south. After he finished, he noticed a large bear snooping outside. What color was the bear?

James B. Rittershaus
102 Kate Drive
New Hyde Park, N. Y.

Answer: The bear was white, since he must have been a polar bear. A house with all four sides facing south can be built only at the North Pole.

Big Money

Suppose someone hires you at a starting salary of 1 cent a day. If your salary is doubled every day you work, how long will it take before you earn a million dollars a day?

Kent Wikarski
22932 Garfield
St. Clair Shores, Michigan

Answer: Only 28 days.

Galileo's Theory

Before Galileo, people thought that a heavy body fell faster than a lighter one. Galileo showed that this was not true by dropping weights from the tower of Pisa, proving that all weights fall at the same rate of speed. But even before he performed the experiment, he reasoned logically that the old idea was false. Can you explain what his reasoning was?

Kenneth Von Kohorn
Pecksland Road
Greenwich, Conn.

Answer: Galileo reasoned as follows: If a light object is attached to a heavy object, then the combination is heavier than either object, and should certainly fall faster than the heavy object alone (according to the old theory). But since the light object falls more slowly than the heavy object, it would slow up the heavy object when attached to it. That means the combination would fall more slowly. This is a contradiction, which means that the old theory obviously must be false. The experiment reinforced Galileo's logic.

Man in the Well

Suppose a man were stuck in the bottom of a well and tried to climb out. Every day he climbs three feet, but at night he slips back two feet. If the well is 23 feet deep, how long would it take for the man to get out? In figuring out this one, don't take anything for granted.

Gary Hynds
8713 Klinedale Avenue
Pico River, Calif.

Answer: Only 21 days. On the morning of the twenty-first day he would be only three feet from the top. On that day he would climb three feet, reach the top, and be out of the well.

Wanted: Brainteasers

[Do you have a favorite brainteaser that you would like to share with other readers? Send the brainteaser, together with the solution, to *Science World.* We will pay $5 for each brainteaser published. Include the name of your school, in addition to your home address, and give your age.]

Project and Club News

(Continued from page 28)

of bacteria. She found that a chemical substance was identified with the bacteria. This chemical dissolved carbohydrates and proteins in foods. A physician who heard of the experiments suggested that all the club members make this their project. The problem was to find out whether this chemical, which could dissolve proteins, could also dissolve blood clots.

The hard-working members of the club have been rewarded with a $2,300 grant from the National Institutes of Health to continue their important research. The junior scientists believe their research may uncover an anticoagulant that would be easier and cheaper to produce than any now available.

Many experiments have been performed during the past two years to isolate the chemical substance and test its effect on blood clots. Like true scientists, the club members make test after test to isolate their findings. Their work is too important to permit any avenue to go unexplored.

Science World wishes these scientists of tomorrow good luck.

Snow Crystal Photomicrographs

It is not as difficult as it may appear to make photomicrographs of snowflakes with which to build your own collection of "diamonds from the sky." You might be interested in doing a science project on snow crystals and such photographs may prove invaluable. Besides enjoying yourselves, you and the other members of your science club may discover some interesting phenomena.

Actually, there is no difficulty in photographing snow crystals, provided the temperature is below −5 degrees C. Simply take your microscope outdoors and set it up in a shady spot. Here it will be protected from the snow and also be chilled to the temperature of the snow.

At temperatures above −5 degrees C. it is necessary to cool your glass slides before placing crystals on them.

To show the details of the crystal's structure, it is best to use oblique illumination. It is important not to slant the light too much, for this will result in darkening the visual field. Adjust the angle of light by hand. The best angle is one that will slightly darken one side of the visual field.

Not only is it possible to get clear pictures of the ruggedness of the surface, but you can also see distinct images of the internal structure of the crystals.

A microscope, camera, warm clothes, ear muffs, and gloves—and you're all set to snap away. When your nose gets cold come inside and develop your photos. Here's hoping you develop some masterpieces.

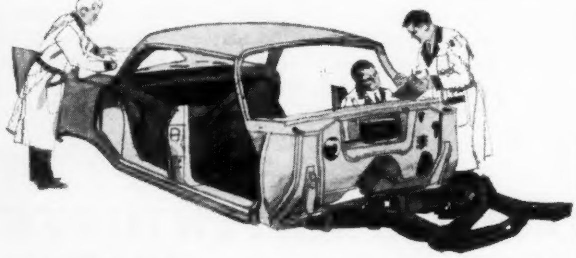
Answers to Crossword Puzzle

(See page 28)

F	A	U	L	T	S	■	P	U	M	I	C	E
O	S	■	O	H	■	W	■	R	E	■	O	R
S	T	Y	■	E	■	E	■	N	■	T	O	O
S	E	E	P	■	R	A	P	■	F	O	L	D
I	R	A	■	T	E	T	O	N	■	N	E	E
L	S	■	H	I	G	H	E	S	T	■	D	S
■	■	M	E	■	■	E	■	■	H	C	■	■
M	E	T	A	M	O	R	P	H	I	S	M	S
■	■	■	T	U	N	■	S	I	N	■	■	■
L	A	P	■	D	■	T	■	M	■	W	A	S
A	X	E	S	■	M	A	P	■	M	I	C	A
V	I	P	■	C	O	L	O	R	■	T	E	N
A	S	■	G	L	A	C	I	E	R	■	S	D

SHAKE, RATTLE, AND RUST BITE THE DUST

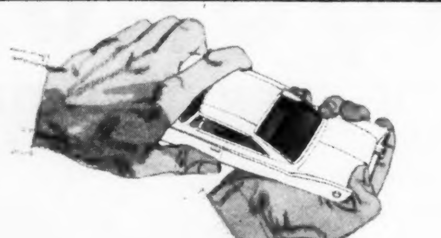
in the 1960 cars from Chrysler Corporation



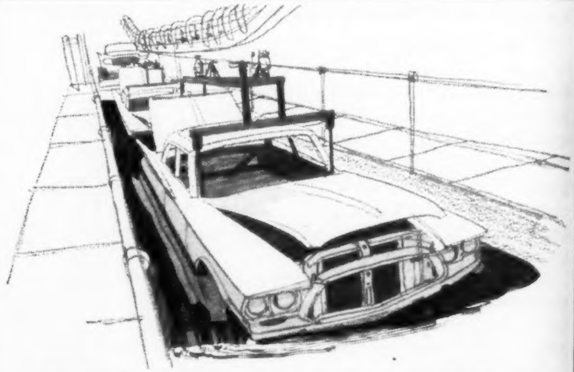
DEVELOPED THROUGH SPACE-AGE ENGINEERING, Unibody combines body and frame into a single solid unit instead of separate units connected by nuts and bolts. Giant electronic computers showed us how to make Unibody quieter and smoother-riding than is possible in earlier "unitized" construction.

A completely new way to put cars together—Unibody Construction—makes these new cars stronger, quieter, roomier—and rust-free for years!

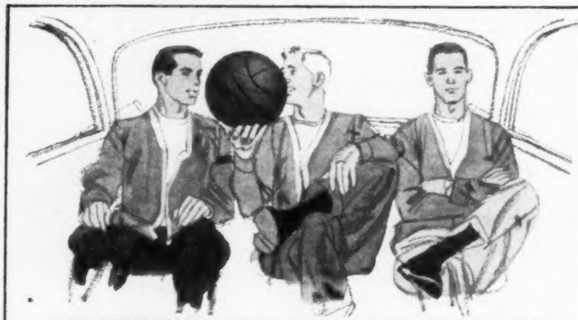
YOU'RE SURROUNDED WITH SILENT STRENGTH. Because it's a rigid yet perfectly "tuned" whole, Unibody silences shakes, squeaks and rattles as no other method of building cars can. In fact, the 1960 cars from Chrysler Corporation are so quiet, you feel as if you're going 10 miles an hour slower than you actually are!



TWICE THE TORSIONAL STRENGTH, 40% more beam strength than previous models. These new bodies are framed like bridge trusses. The electronic computers told us how to get rid of useless bulk and put strength where it is needed. Result? You get a wonderful feeling of security that makes driving more enjoyable than ever.



NEW METAL TREATMENT STOPS RUST YEARS LONGER. All metal is specially cleaned to remove oil traces—and the body is dipped a total of *seven* times. Metal panels treated this new way showed no rust after salt-spray tests equal to 12 years of outdoor exposure—five times longer than otherwise identical panels.



MORE ROOM INSIDE without raising the roof or stretching the car. You can sit up tall or stretch out and relax in these cars—and they're no higher and no longer than last year's models. Unibody let us lower the floors and make the doors wider, too. And there's no dogleg in the front door opening to bang your knees on.

That's Unibody—you can't see it, but you'll know it's there the moment you put one of these new 1960's on the road. Why not see for yourself. Stop in at the dealer's with Dad for a drive that will bring out the difference great engineering makes!

The Quick, the Strong, and the Quiet

from CHRYSLER CORPORATION

VALIANT • PLYMOUTH • DODGE DART • DODGE • DE SOTO • CHRYSLER • IMPERIAL